INTRODUCTORY PSYCHOLOGY FOR TEACHERS

E. K. STRONG, Jr.

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BY

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BALTIMORE
WARWICK & YORK, Inc.
1920

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To My Father and Mother

PREFACE

Certain principles have been established as fundamental to good teaching. Theoretically, all psychologists are agreed that a course of study should proceed from the known to the unknown and from the concrete to the general; that students should learn by doing; that the problem or project method of teaching is superior to memorization of a textbook; that functional not faculty psychology should be taught; that individual differences in students should be taken into account; that a beginning course should be designed for the benefit of the great majority who never go farther; etc.

The aim of this course is to meet these and other ideals of teaching in an introductory course of psychology designed primarily for the use of prospective teachers. Instead of beginning with the most uninteresting phases of psychology and those most unknown to students, the course takes up concrete experiences of everyday life, relates them to the problems of learning and individual differences, and so develops these two topics. Each general principle is discovered by the student out of his own experience in solving specially organized problems. Only after he has done his best is he expected to refer to the text and by then the text is no longer basic but only supplementary, clearing up misunderstandings and broadening the whole viewpoint. Behavior as a whole is considered from the start; gradually it is subdivided and subdivided, so that finally such topics as "memory" or "attention" can be discussed without fixing in the mind of the student the idea that they are separate entities. And in general the course is prepared on the assumption that the majority of students are never going to specialize in psychology and should consequently be given the most interesting and useful facts and principles of psychology, regardless of whether or not they are usually reserved for graduate students.

As the author has planned it, this course is followed by two companion courses. The first covers the general topics of how to remember, how to get attention, economical learning, analysis and reasoning, method of teaching, drill and thought work, development of ideals, how to study, etc. The second course takes up man's instinctive equipment and applies both the instinctive and habitual principles of behavior to social, educational and industrial problems. Following such a broad survey of the most useful phases of psychology, can come the more detailed and systematic study of psychology on the part of students who are genuinely interested and can devote more than a year to the subject.

The course is conducted in a radically different way from prevailing courses. The student is immediately introduced to problems of behavior taken as a whole and only after he is fairly familiar with psychological procedure, terminology and point of view is he given his psychological background. The odd numbered lessons present problems to be solved and the even numbered lessons supply in a general way answers to the problems, together with a broader interpretation of the facts than the average student will discover for himself. For example, Lesson 7 outlines the familiar mirror-drawing experiment. This is performed, say on Monday. That night the experiment is written up and handed in at the class-hour on Tuesday. That hour is devoted to a general discussion of what was discovered in the experiment on the learning process. At the close of the hour Section No. 4 is given the class containing Lessons 8 and 9. The class reads over Lesson 8 on Tuesday evening. At the next class-hour Lesson 9 is taken up in the laboratory in the same way as Lesson 7. Each topic is handled as follows: (1) the student performs an experiment illustrating the principle to be emphasized, (2) he solves the problem as best he can and hands in his report, (3) he has the benefit of a class discussion upon the subject at the next class-hour, (4) he reads over what the author has to say on the subject, (5) he receives back his own corrected paper on the subject, (6) he reviews the subject once about every eight class-periods. All class discussion is based upon the laboratory experiences, not upon the author's presentation of the subject. The latter is only a supplementary aid, to correct misunderstandings and to furnish the student a standard by which to check his own work.

Individual differences are amply provided for in such a procedure. The poor student obtains a concrete grasp of the main points of the course. The able and industrious student adds to this minimum a very much broader and more detailed understanding of the whole subject. The rate of progression is such that even the ablest student realizes that he is not getting all that there is in the course. All are thereby stimulated in a way that is not true when the rate is slow enough to discuss thoroughly every detail mentioned in the text.

The course can be conducted as a 4-hour course over one quarter, or 2 hours over two quarters, or 3 hours over one semester. The laboratory equipment can be supplied for $100.

The text is printed as a book or in the form of 17 booklets. The advantage of the booklets is to prevent the student reading ahead. This is important as the even numbered lessons contain the answers to most of the problems. Where students read ahead they lose the training resulting from working problems out for themselves. Experience

has shown they do about as good work as those who do not read ahead during this first course. In the second course, however, they commence to fall by the wayside, due to a lack of grasp of the subject matter which is secured by students who work out the principles for themselves.

So many have been of general inspiration and help in this work that space will not permit special mention of their services. Several who have used the text in its mimeographed form have aided in a very definite way in revising and clarifying sections. They are: Miss Kate Anthony, State Normal School, Cape Girardeau, Mo.; Professor C. M. Faithful, Tennessee College, Murfreesboro, Tenn.; Professor S. C. Garrison, George Peabody College for Teachers; Professor W. A. McCall, Teachers' College, Columbia University, and Professor J. Roemer, Sam Houston Normal Institute, Huntsville, Texas. Professor Y. Shoninger, George Peabody College for Teachers, helped me very considerably in writing up the description of a "sight-spelling lesson." To all these I owe very much. But I owe most to my wife, who has aided both in matters of expression and of content and has checked tables and "proof read" every new form of the material, whether script, typed or mimeographed or printer's proof.

I desire also to express my appreciation for the courtesy of authors and publishers for permission to reproduce illustrations. I am indebted to The American Book Company for a figure from D. J. Hill's 'The Elements of Psychology'; to Dr. S. A. Courtis and the Department of Education, University of Indiana, for a figure from the 'Second Indiana Educational Conference Report'; to Dr. Courtis and The World Book Company, for figures from 'Standard Practice Tests'; to Dean J. R. Angell and Henry Holt and Company for figures from 'Psychology'; to Dr. J. D. Lickley and Longsmans, Green and Company, for a figure from 'The Nervous System'; to Dr. W. B. Pillsbury and The Macmillan Company for a figure from 'Fundamentals of Psychology'; and to Dr. E. L. Thorndike for figures from 'Educational Psychology', Vol. III.

Carnegie Institute of Technology. August 1, 1919.

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INTRODUCTION

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SOME PHYSIOLOGICAL ASPECTS OF PSYCHOLOGY

LESSON 1—WHAT IS PSYCHOLOGY?*

Some of you are doubtless familiar with the story from which the following incident is quoted. But it bears repeating.

Sam had never told his love; he was, in fact, sensitive about it. This meeting with the lady was by chance, and altho it afforded exquisite moments, his heart was beating in an unaccustomed manner, and he was suffering from embarrassment, being at a loss, also, for subjects of conversation. It is, indeed, no easy matter to chat easily with a person, however lovely and beloved, who keeps her face turned the other way, maintains one foot in rapid and continuous motion thru an arc seemingly perilous to her equilibrium, and confines her responses, both affirmative and negative, to "U-huh."

Altogether, Sam was sufficiently nervous without any help from Penrod, and it was with pure horror that he heard his own name and Mabel's shrieked upon the ambient air with viperish insinuations.

"Sam-my and May-bul! Oh, Oh!"

Sam started violently. Mabel ceased to swing her foot, and both encarnadined, looked up and down and everywhere for the invisible but well-known owner of that voice. It came again, in taunting mockery.

"Sammy's mad, and I am glad,
And I know what will please him,
A bottle of wine to make him shine,
And Mabel Rorebeck to squeeze him!"

"Fresh old thing!" said Miss Rorebeck, becoming articulate. And, unreasonably including Sam in her indignation, she tossed her head at him with an unmistakable effect of scorn. She began to walk away.

"Well, Mabel," said Sam plaintively, following, "it ain't my fault. I didn't do anything. It's Penrod."

"I don't care—" she began pettishly, when the viperish voice was again lifted.

*The relationship between class-room work and assignments will be shown in each Section by an outline, as follows:

CLASS HOUR	IN CLASS	WRITE-UP	READ
1	Introduction		Lesson 1
2	Discuss Lesson 1		Lesson 2
3	Visit 1st Grade	Lesson 3	

"Oh, oh, oh!
Who's your beau?
Guess I know:
Mabel and Sammy, oh, oh, oh!
I caught you!"

Then Mabel did one of those things which eternally perplex the slower sex. She deliberately made a face, not at the tree behind which Penrod was lurking but at the innocent and heartwrung Sam. "You needn't come limpin' after me, Sam Williams!" she said, tho Sam was approaching upon two perfectly sound legs. And then she ran away at the top of her speed.

"Run, nigger, run—" Penrod began inexcusably. But Sam cut the persecutions short at this point. Stung to fury, he charged upon the sheltering tree in the Schofield's yard.*

Why is it that this account is interesting to us? Why did Sam and Mabel enjoy being together? Why were they so nervous and uneasy? Why did Penrod call out as he did? Why did Mabel get mad at Sam? Why did she run away? Why did Sam get mad? What happened when Sam reached Penrod?

At this point some of my students have seemed to stop and, with lifted eyebrows, to question silently, "Is this a game of twenty questions? and twenty foolish questions at that? Can this be psychology?

It is. All these questions are real psychological problems, quite as pertinent to the science of psychology as the dignified and dry-as-dust queries you doubtless expected.

What then is psychology?

In commencing any new course of study it is necessary to have some idea of what the whole thing is about. At the same time it is extremely difficult to obtain a clear notion since most of the details are unknown to the beginner. It is only after one has experienced details that he is in a position to understand any summary of them. Consequently the following definition is just to aid the student in orienting himself. Only toward the end of the course will he be prepared to grasp its full meaning.

Psychology may best be defined as the science of behavior.

There is the definition. The matters dealt with in the next ten sections will give some of the various fields included in its bounds.

(1) A crowd surrounded the automobile of Dr. John Linder of 1509 Eastern Parkway, Brooklyn, yesterday, when the physician stopped at Glenmore and Vesta Avenues after a dog had dodged beneath the auto's wheels and had been killed. There were men and

*Booth Tarkington—"Penrod and Sam," 1916, pp. 220-222.

women in the throng and they seemed to think that the physician had not tried to avoid the dog.

Dr. Linder endeavored to explain that the most expert of motorists could not have dodged the dog, which ran barking beside the wheels of his auto and finally slipped under them. The crowd muttered angrily about motorists who had no thought for human lives, let alone the life of a dog, and Dr. Linder, realizing that the crowd soon might become dangerous, tried to start his car.

His action aroused several men in the crowd who had been working themselves into a fury, and one of them struck out at the doctor with his fist. The physician ducked, and reaching in his pocket, jerked out a glittering object of nickel which he thrust into his assailant's face, exclaiming:—

"Stand off. Get back from this car. I'll shoot the first man who interferes with me."

The man who had struck at the physician, with all the rest of the crowd, fell back hastily, and Dr. Linder, seizing the opportunity, applied the power to his car and slipped away. John Cargill, a blacksmith of the neighborhood, noted the number of the doctor's car, however, and hurried to the New Jersey Avenue Court where he got a summons for the physician, calling on him to show cause why he shouldn't be punished for violation of the Sullivan Law against carrying weapons. The physician had scarcely arrived at his home when the summons was served and he hurried back to court in his automobile.

Cargill was present and Dr. Linder, after explaining the accident to Magistrate Naumer, declared that Cargill had been particularly aggressive.

"He had a mob at his back," said the doctor, "and I was really afraid they would attack me."

"But your revolver?" questioned Magistrate Naumer. "Do you not know that under the present law you may not carry a weapon without a permit?"

"Why, I only threatened the crowd with this," replied the physician as he pulled something from his pocket and snapped it into the Magistrate's face. There was a small report, and Magistrate Naumer clutched spasmodically at the desk in front of him. Then he burst into a laugh as he observed the glittering nickel cigar lighter which Dr. Linder held in his hand.

Dr. Linder would not make a charge against Cargill, and the smith hurried out of the courtroom to the accompaniment of laughter in which every one joined.*

*New York Times, 1911

Why should a crowd become angry because a dog had been killed? Would Cargill have become as angry if he had been alone as he did when surrounded by a crowd? Why did the crowd think Dr. Linder had a gun? Why did Cargill want the doctor arrested? Why did the crowd in the courtroom all laugh at Cargill? Why have you also enjoyed Cargill's discomfiture?

(2) A frequent sight is that of little boys fighting. Why do they like to fight? Why does a woman want to stop them fighting? Why will men pay half a million dollars to sit in the broiling sun and see a prize fight?

(3) Consider any advertisement before you. What situation is depicted? Does it in any way express your feelings? Could the advertisement be changed so that it would present a situation that would make you really want the commodity advertised?

(4) Consider the following cases:—

(1) A college professor discovers that a wealthy old bachelor keeps a large amount of money hidden in his house. After weeks of clever work he discovers where this money is kept and finally obtains a pass key. One night he enters the house, secures the money and on being discovered by the bachelor, kills him.

(2) A young man by the name of Black from a prominent family is engaged to marry Miss Smith. Mr. Jones, altho knowing of the engagement, deliberately makes love to Miss Smith and eventually supplants Black. When Black discovers the fact, in a fury of rage, he kills Jones.

(3) C is attacked by a burglar in his own home and after a struggle, kills the burglar.

(4) D recklessly drives his auto thru the streets of a village and kills a young boy.

(5) E attacks two little boys in the woods and after torturing them for sometime, finally cuts one of them to pieces with a razor.

In these five cases a man has killed another human being. Each is a murderer. Why shouldn't all be hung for their crime? Your answer, of course, is that the circumstances are different. Can we conclude that the five men are different sorts of men on the basis of the circumstances which are presented? How can we evaluate their conduct? in terms of their action, or in terms of the situations which confronted them, or in terms of both situation and response?

(5) All respectable school teachers spend some time every year condemning prize fights, bull fights, gambling, drinking, etc.

Especially is this true of women teachers. Yet two of my acquaintances when visiting the exposition at San Diego several years ago, rode down to Tia Juana, in Mexico, and very much enjoyed a prize fight, lost a quarter at each of the gambling tables in the "joint" there, and afterwards loudly berated their fate because they arrived too late for the bull-fight. Is it conceivable that the difference in the situations which confront them at home, in the school, or at Tia Juana, is responsible for strong condemnation of a prize fight in one place and attendance at and enjoyment of one in another place?

Do you think it possible to set down all the details making up the situation which confronts one and then to record the response made to this complex situation? If we knew all the details would we be able to prophesy what a person would do? Cannot I be certain that you will say to yourself "7" and then "cat" after reading the next two sentences? What does 3 and 4 make? What does c-a-t spell?

(6) A man, walking with a friend in the neighborhood of a country village, suddenly expressed extreme irritation concerning the church bells, which happened to be pealing at the moment. He maintained that their tone was intrinsically unpleasant, their harmony ugly, and the total effect altogether disagreeable. The friend was astonished, for the bells in question were famous for their singular beauty. He endeavored, therefore, to elucidate the real cause underlying his companion's attitude. Skilful questioning elicited the further remark that not only were the bells unpleasant but that the clergyman of the church wrote extremely bad poetry. The causal "complex" was then apparent, for the man whose ears had been offended by the bells also wrote poetry, and in a recent criticism his work had been compared very unfavorably with that of the clergyman. The "rivalry-complex" thus engendered had expressed itself indirectly by an unjustifiable denunciation of the innocent church bells. The direct expression would, of course, have been abuse of the clergyman himself or of his works.

It will be observed that, without the subsequent analysis, the behaviour of the man would have appeared inexplicable, or at best ascribable to "bad temper," "irritability," or some other not very satisfying reason. Most cases where sudden passion over some trifle is witnessed may be explained along similar lines, and demonstrated to be the effect of some other and quite adequate cause. The apparently incomprehensible reaction is then seen to be the natural resultant of perfectly definite antecedents.*

*B. Hart, The Psychology of Insanity, 1912, p. 73-74.

Did you ever "fly off the handle" at a perfectly innocent person? Have you ever ridiculed a person's clothes when the only trouble with the clothes was that the wearer had beaten you out in an examination? If your friends were aware of one or more of such complexes, as Hart has described above, would it help them in understanding your conduct? Would it help them to prophesy what you would do next?

(7) **Now I want to be a nice, accommodating patient; anything from sewing on a button, mending a net, or scrubbing the floor, or making a bed. I am a jack-of-all-trades and master of none! (Laughs; notices nurse.) But I don't like women to wait on me when I am in bed; I am modest; this all goes because I want to get married again. Oh, I am quite a talker; I work for a New York talking machine company. You are a physician, but I don't think you are much of a lawyer, are you? I demand that you send for a lawyer. I want him to take evidence. By God in Heaven, my Saviour, I will make somebody sweat! I worked by the sweat of my brow. (Notices money on the table.) A quarter; twenty-five cents. IN GOD we trust; United States of America; Army and Navy Forever!"***

The preceding paragraph and the one that follows are verbatim copies of the remarks of two different individuals. The former is that of a maniac and illustrates what is called "flight of ideas"; the latter is that of a dementia præcox patient and illustrates "incoherent speech."

"What liver and bacon is I don't know. You are a spare; the spare; that's all. It is Aunt Mary. Is it Aunt Mary? Would you look at the thing? What would you think? Cold cream. That's all. Well, I thought a comediata. Don't worry about a comediata. You write, he is writing. Shouldn't write. That's all. I'll bet you have a lump on your back. That's all. I looked out the window and I didn't know what underground announcements are. My husband had to take dogs for a fit of sickness.**

Offhand one wouldn't say that there was any order or system to these two paragraphs, particularly the second one. And experts have more or less held that view until recently, when careful study commenced to show that there were rules and principles underlying even the ravings of the insane. Some day these will be as thoroughly understood as are physical and chemical laws today.

(8) **Beliefs have been held as peculiarly one's own, and so intangible that no one until recently has dreamed of measuring them.**

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*J. R. deFursac, Manual of Psychiatry, translated by A. J. Rosanoff, 1908, p. 71.
**J. R. deFursac, op. cit., page 72.

Yet below there are given nine beliefs making up a sort of scale extending from absolute belief (100) thru doubt (0) to absolute disbelief (-100). This scale is very imperfect, being based on but a limited number of men and women, but it illustrates what can be done along the line of measuring intangible things.

2 plus 2 equals 4.	99
There exists an all wise Creator of the world	73
A house-fly has six feet	47
The most honest man I know will be honest ten years from now.	21
"Blessed are the meek for they shall inherit the earth."	-2
Magna Charta was signed in 1512.	-22
"It never rains but it pours."	-53
"Only the good die young."	-74
2 plus 4 equals 7.	-99

If one wishes to determine, for example, how strongly he believes that "dark-haired girls are prettier than light-haired ones," he can compare it with those statements above and so obtain a rating for it. The writer cannot comprehend why the average man should rate this belief half-way between the fifth and sixth beliefs on the "scale," and the average woman half-way between the sixth and seventh. But they do.

(9) From the New York Times of about May 1, 1914, is quoted the following editorial comment on an article by a Superintendent of a Connecticut brass works which appeared in *The Iron Age*.

At these works there was recently constructed a long incline up which heavy loads were to be wheeled in barrows, and premiums were offered to the men who did or exceeded a certain amount of this labor. They attempted it vigorously, but none succeeded in earning any of the extra money, instead they all fell considerably below the fixed task.

Prompt investigation by an expert disclosed that the trouble lay in the fact that the men were working without sufficiently frequent periods of rest. Thereupon a foreman was stationed by a clock, and every twelve minutes he blew a whistle. At the sound every barrowman stopped where he was, sat down on his barrow, and rested for three minutes. The first hour after that was done showed a remarkable change for the better in accomplishment; the second day the men all made a premium allowance by doing more than what had been too much; and on the third day the minimum compensation had risen, on the average, 40 per cent, with no complaints of over-driving from any of the force.

Apparently a man can do more physical labor by working 12 minutes and resting 3 minutes out of every 15 than he can if he works all of every 15 minute period throughout the day. This principle is one of the fundamental principles underlying scientific management, which has been so much discussed of late in various publications. Possibly this principle might be utilized by you in your daily life. But you may need to know considerably more of the whole subject before making the proper application of it to your particular type of work.

(10) How long does it take to say the alphabet? And how much time is required for one to say it backwards? And having said it once will one be able to recite it faster on a second trial? In Plate I is shown graphically just how much time is required to recite the alphabet forwards (i. e., 6.0 seconds) and backwards (i. e., 46.0 seconds), and furthermore how much time is required for each successive recitation up to twenty times. An average adult will decrease his time from 6.0 to 4.0 seconds in the one case and from 46.0 to 12.5 seconds in the second case.

Why do we thus improve with practice? And how is the improvement accomplished? Where are the changes registered?

Such a simple performance as that of saying the alphabet is after all very complicated. Watching a child mastering its intricacies gives us some little appreciation of this fact. Involved in this case are many of the problems of education—problems which are also fundamental psychological ones. We meet similar problems on every hand. Today a human being may be unable to use a typewriter, or swim, or dance, or play golf, or run a motor boat; he may know nothing about banking, or politics, or how to fry a steak, or make a cake, or trim a hat. Yet in a short time we may find he has acquired any or many of these performances. This is such a common occurrence we pay little attention to it. But the more we consider the matter the more we should marvel at it. How does a person learn to typewrite? How comes it that his fingers hit the right keys altho his eyes are on the sheet from which he is copying? Or take another experience thru which we have all gone. How have we come to know that 7 plus 6 is 13 or that 7 times 6 is 42? Have all persons learned these two performances in the same way? Is there one best way to learn them? If so, what is it? Why is it that some never can learn such things,—for we have known boys and girls and even men and women who can't.

What has been given in this chapter could be extended indefinitely so as to bring in incidents dealing with the differences between whites and negroes or Chinese: problems dealing with poverty and its origin, or

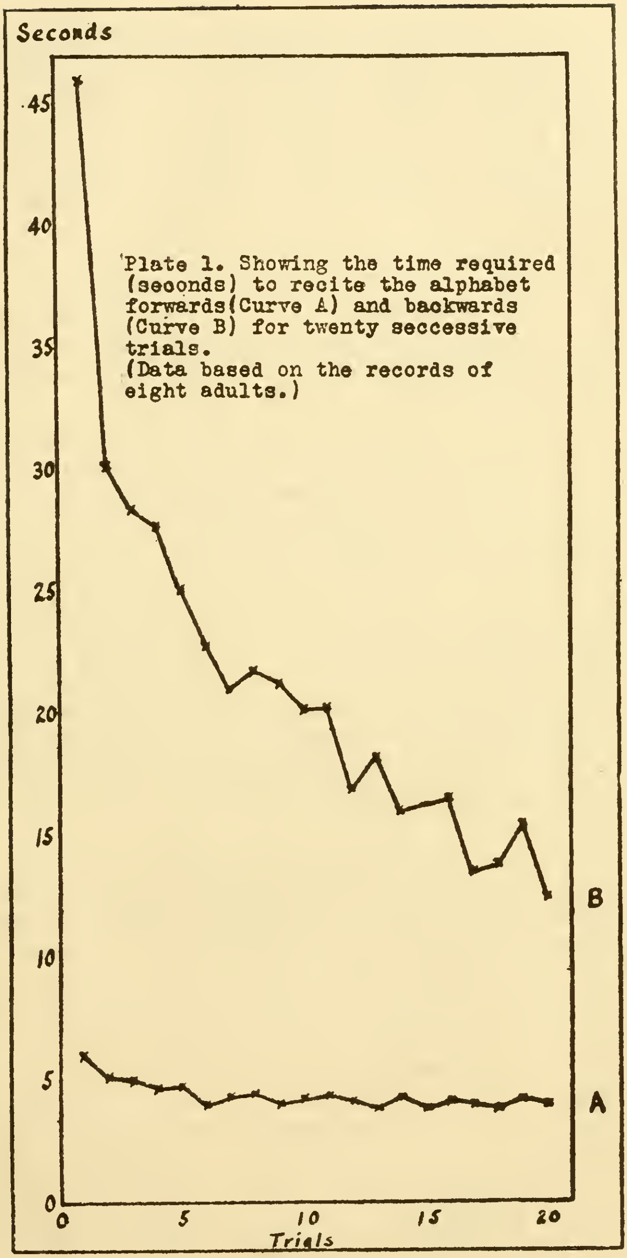


Plate 1. Showing the time required (seoonds) to recite the alphabet forwards (Curve A) and backwards (Curve B) for twenty seccessive trials.
(Data based on the records of eight adults.)

with success and its causes; questions concerning delinquency in court or truancy in school; methods of selecting salesmen for a great corporation or telephone girls for the Telephone Co. In fact, it could be extended so as to include any and every relation that exists or may ever exist between man and man. All of these subjects may be discussed and many are discussed in other divisions of knowledge, such as history, economics, sociology, anthropology, psychiatry, criminology, advertising, salesmanship, education, etc., but all belong in the science of psychology.

Psychology has been defined as the *science of behavior.* It is concerned with the orderly presentation of the facts and laws which underly human conduct. It not only includes this but also takes in the whole realm of living beings. Today psychologists are not only studying how man behaves and how he learns but also how rats, and guinea pigs, and monkeys, and birds, and even earthworms, behave and how they learn. This work with animals may seem foolish but it has already led to a better understanding of many phases of human behavior and undoubtedly will lead to very much more.

Psychology has not always been defined in this way. In earlier days it was defined as the "science of the soul" or the "science of mind." Both of these definitions led to insurmountable difficulties and have been discarded. A third definition, i. e., "psychology is the science of consciousness," is still held by many psychologists. With such a definition one is led to emphasize conscious acts and more particularly the content of consciousness to the exclusion of such phenomena as are popularly grouped under the headings of behavior and conduct. But of late, the definition upheld in this book has been adopted by more and more psychologists.

And they are deliberately broadening the field of psychology so that it shall include all of man's activity of every sort and kind. At the present time it is quite clear that those who uphold the definition of psychology as the science of consciousness are little or not at all interested in applied psychology, while those who have espoused the definition of psychology as the science of behavior are also those who have been most active in the application of psychology to advertising, salesmanship, vocational guidance, medical and legal problems, etc.

Such a great subject as man's behavior cannot be covered in a few pages or in a few weeks. A beginning course must commence at some point and develop it in a systematic manner. This means that only certain things can be considered here. What shall those things be? Primarily, we shall consider how man learns. This will lead into many related phases of man's conduct and, of course, if quite thorough

would sooner or later touch all of man's behavior. But to attempt such a complete investigation would be too tremendous an undertaking. We shall have to be content with a general survey of the learning process with special reference to learning in the school. We shall take up one example after another; we shall actually learn things in order to have fresh in our minds just how it *feels* to learn; we shall compare our progress with that of others in order to see how individuals differ; and we shall compare one performance with another in order to draw up general principles and laws which will explain what learning is and how it is accomplished.

LESSON 2—STUDY OF A SIGHT-SPELLING LESSON

At the next class-hour you will witness a "spelling" lesson in the first grade.*

Here little children are learning to write a given word upon the board. The emphasis is upon writing the whole word and not upon the letters in the word. And as the emphasis thruout the first grade is upon whole words, some teachers maintain that spelling is not taught until the second or third grades. We will not quarrel with them. We will note, however, how the little child is led step by step to the point where he can write a word on the board after seeing his teacher do it.

The Sight-Spelling Lesson is employed by many teachers in the elementary school to train children in spelling. It consists essentially of showing a word for a moment and then requiring the child to reproduce the word in writing. It is one of the methods used in training pupils to read words, and even sentences, before they know their letters.

THE RELATIONSHIP OF A "SIGHT-SPELLING" LESSON TO LESSONS IN READING AND WRITING.

In order to get the right setting for the understanding of a sight-spelling lesson it will be necessary to go back and get clearly in mind just what a teacher has attempted to accomplish before commencing the teaching of spelling. This preliminary work as given in a typical school can be roughly divided into four steps:

First. The children relate their experience in class. Day after day the children are encouraged and led to talk about things that interest them.

Second. These experiences are written on the board. On a Monday about three weeks after the opening of school, the children are asked for example, to tell their experiences since last Friday. One little boy

* In some cities this method of teaching is not employed. In such cases the 3rd class hour can profitably be spent in a discussion of this lesson.

may reply as follows, his sentences being written on the board as he gives them:—

"I went to the country on Saturday.
I played with Fred.
We played leapfrog.
We played ball.
We had a happy time."

The children are here given a clear conception of the fact that what they say may be recorded on the board—that writing has something to do with their very thoughts.

Third. Drill is commenced leading to "recognition" of the sentences, phrases and words. The teacher asks: "Who can find where it tells, 'I went to the country on Saturday?' Who can find where it tells, 'We played leapfrog?' Where does it say, 'We played ball?' Where does it say, 'I played with Fred?' ", etc. At first these sentences are remembered largely because of their *position* on the board. The child remembers the order in which the sentences occurred and makes his guesses accordingly. Soon, however, the recognitions are made in terms of the *form* of the whole sentence.

Right from the start whole sentences or phrases or words are thus drilled upon. Slowly for some children, more quickly for others, the forms of the words or sentences are remembered and connected with their sound. As the word is pronounced by the teacher and then pointed to by some child, the teacher rewrites the word and calls their attention to the fact that "This (pointing to the written word) always says 'ball' ". After three or four days of such work in which the question has been all the time, "where is this," the children are ready for the fourth step.

Fourth. Drill is given leading to "recall" of the sentences, phrases and words. Here the characteristic question is, "What does this say?" The child here must verbally reproduce from memory the words and sentences as the teacher points to their written symbols. Here again, as the words are pointed to and then named by the child, the teacher frequently rewrites the word (for example, "ball") at the side of the sentence and says, "This always says ball."

At this point writing may be introduced to the child. The teacher choosing some particular word, asks the children to watch her write it. The children watch the word as it is written and after it has been erased go to the board and write it as best they can.

The fourth step is really two steps—one deals with the recall of the sound of the word when it is seen (reading); the other deals with the reproduction of the form of the word after it is seen (writing). The

former means that the child will properly move the muscles of his speech organs when confronted by the sight of the word; the other that he will properly move the muscles of his fingers and arm when confronted by the sound of the word or after having seen the word.

In a diagramatic way we can illustrate these two processes as follows:—

Reading.	Seeing word "ball"	saying the word "ball."
Writing.	Hearing the word "ball"	writing the word "ball."
"	Seeing word "ball"	writing word "ball."

The method of developing the second part of this process of "re-call" is called "sight-spelling." It might more properly be called "sight-writing," for the emphasis in the drill is upon a reproduction of the form of a word previously seen, but not now present to sight.

THE SIGHT-SPELLING LESSON IN DETAIL.

The procedure in a sight-spelling lesson is as follows: The teacher pronounces the word "ball," then writes it on the board at the usual rate of writing, then pronounces the word "ball" again, allows the children to look at it for a moment, and erases it. Then she tells them that she is going to call upon them to go to the board and write the word there. She then rewrites the word, pronouncing it as she does so, and may have the class also pronounce it. After they have looked at it for a moment, she erases it. Then one or more children are sent to the board to write the word. Some of the children may get it correctly while others will fail. Those who have failed may be given one or more chances to see the word written again or not as the teacher is disposed. Then another word is presented and the procedure is repeated. (One of the most important elements in the whole process is the matter of having the child watch the teacher as she writes the word. It is not enough for the child to see the completed word, *he must see it as it is written.* Otherwise, he may attempt to write it backwards or in some other way than the correct method.)

As this drill is continued each child learns how best to utilize his time while the word is exposed on the board so as to be able to write the word later. These methods which children adopt have not been worked out by adults as yet. When they are understood in all probability we shall be able to help the child develop the best method for him. What actually takes place, no matter how it is done, is that the child sees the word written on the board and then after it is erased goes to the board and reproduces the form of the word as he has previously seen it. (Of course it is not meant that the reproduction is anything but an approximation at first, but with practice there results a fairly good imitation of the teacher's form.)

SUMMARY

The above paragraphs have presented (1) what a sight-spelling lesson is, (2) the relationship between a sight-spelling lesson and other lessons in the first grade which have led up to it and (3) the detailed elements in a sight-spelling lesson We now have a general idea of the relationship of spelling to conversation (oral expression), reading and writing.

A clear understanding of these points will aid you greatly in grasping and appreciating each move of the teacher and each response of the children when you witness the class exercise.

LESSON 3—BEHAVIOR ANALYZED INTO ITS TWO COMPONENTS, SITUATION AND RESPONSE

At this stage in the course it will be impossible to discuss the various steps in detail relating to the sight-spelling lesson or to work out the various psychological principles involved in any one step. To do so properly would necessitate a fairly complete knowledge of psychology—the very thing we, of course, do not have at our disposal just now. Before this course is finished, however, we shall return to this lesson-method and attempt to understand the psychological principles underlying it.

For the present it will be sufficient to get clearly in mind one big conception which the following three questions and their answers will present.

What is the object of the lesson? Evidently, to teach the children how to spell the words presented. Or possibly a better answer is,—to arrange matters so that the children will learn the spelling of certain words. Consequently, every detail in the whole lesson (every act or idea of teacher or child) is related to this central proposition "the child learning." (And conversely, if there is any detail which does not actually aid the child to learn, it is out of place.)

How may all the details in the entire lesson be divided into two groups as they relate to the child's learning? On the one hand the child *sees and hears* certain things; that is, the child is influenced by certain things and, on the the other hand, the child *does* certain things. All the actions of the teacher, whether spoken words, written words, or gestures—all influence the child. Likewise, all the actions of other children in the room influence the child. And because of all this the child makes certain responses. Obviously then the details in any lesson fall into the two groups, (1) those which influence the child, and (2) those which constitute the child's reaction.

How may we designate these two groups of details which make up the spelling lesson? All those details of the lesson which go to influence the child, all combined together, we may call the *Situation*. And all those details which constitute what the child does, we may call the *Response*.

To illustrate these two terms, take this single incident in a spelling lesson. Following a discussion of a "leaf" and the writing of sentences on the board concerning a leaf the teacher then turns to the matter of teaching the writing of the single word. She turns and writes the word "leaf" on the board. Pointing to the word on the board, she announces, "This is the word leaf." Then she erases the word. "Now I am going to write the word 'leaf' again on the board. I want you to watch carefully and see how I do it. After I have written it on the board, I am going to erase it. Then I am going to ask you to come to the board and write it. Now look carefully and get a good picture of 'leaf'." She then writes the word on the board, waits a moment, and then erases it. Then she calls on Carl to go and write the word on the board. Carl goes to the board and writes the word in his crude style of handwriting.

The *Situation* and the *Response*, as relating to Carl, are made up as follows, commencing at the point where the teacher writes the word "leaf" the second time:—

SITUATION	RESPONSE
1. Carl in school. 2. Presence of teacher and schoolmates. 3. Preceding events concerning a "leaf." 4. Teacher's instructions about noticing the word on the board and then reproducing it after she had erased her writing.	General state of attention (1) to class, (2) to teacher, and (3) to specific topic under discussion.
1, 2, 3, and 4 above. 5. Teacher writes the word "leaf" on the board. 6. Teacher erases word. 7. Teacher calls on Carl to write word on board.	4. Carl rises from seat, (5) walks to board, (6) writes word "leaf" on board, and (7) returns to his seat.
1, 2, 3, and 4 above. 8. Teacher nods her approval of his performance.	8. Carl feels pleased.

It is evident that the *Situation* comprises all the details which influence Carl in any way, while it is also evident that the *Response*

comprises all the details of Carl's behavior in responding to the situation. It is equally evident that the Situation and the Response are very complicated, being made up of many details.

The first point to get in this course is that the learning process can be and must be resolved into the two factors "Situation" and "Response." All learning is the doing of something (Response) because of the influence exerted by certain other things (Situation.)

ASSIGNMENT TO BE HANDED IN AT THE 4TH CLASS-HOUR.

1. Prepare a list of 50 situations in daily life which will ordinarily produce a certain response. List them as follows:

SITUATION	RESPONSE
1. Stick a pin into some one.	Person jumps.
2. Sudden noise.	Person jumps.
3. Letters "c-a-t" sounded.	Person thinks "cat."
4. "2 plus 2" seen.	Person thinks "4."
5. Man meets woman he knows on the street.	Man raises his hat.
Etc.	

2. Be prepared to discuss what you saw in the school room in terms of *situation* and *response.*

LESSON 4—BEHAVIOR ANALYZED INTO ITS COMPONENTS SITUATION AND RESPONSE (Continued).*

In Lesson 3, we found that all the details in any lesson may be divided under the two heads, situation and response. Just to strengthen our grasp on this fact let us prove it in another case. We will take the method of teaching reading as given in Lesson 2, and consider not the behavior of a single person but the general principles underlying the behavior of all learners.

Since language is the *sine qua non* of reading we may say that the earliest steps in such learning are taken before the child's first birthday. A probable situation is the entrance of the father and the mother's statement, "Here comes dadda." If the baby happens to make a noise immediately thereupon, which approximates in any way the word "dadda," it will be greeted with wild enthusiasm by the parents, which will arouse the interest and pleasure of the baby. All of the baby's accidental successes will be so delightfully welcomed; his inopportune remarks ignored. After many such occurrences, the presence of the father and the sound of the word "dadda" will practically always cause the baby to say "dadda." After still more practice the sight of the father will in itself be sufficient to cause the baby to call him by name. For the situation has become linked to its appropriate response in the baby's mind.

Many words are learned in like manner. The vocal organs are increasingly practiced by crying, cooing, laughing and chance expressions, until the child has gained the ability to make all the sounds in the language. After this the vocabulary grows rapidly as names can be repeated after one or two hearings.

In all cases we have first the presence of the object and the sound of the name calling up the pronunciation of the name. After this is acquired the mere presence of the object is sufficient to induce the response of the word. Later the physical presence of the object is unnecessary. The ability to express ideas, desires, etc., develops.

Before the child begins to read, then, it has already learned that spoken words stand for visible objects. He has now to learn that visible words stand for spoken words, that there can be two situations leading to the same response.

The object  equals spoken "flag."

The word "flag" equals spoken "flag."

*CLASS-HOUR	IN CLASS	WRITE UP	READ
4	Discuss Lesson 3		Lesson 4
5	Experiment, 5	Lesson 5	

The ability to pronounce the word when one sees it in written form is fundamentally the ability to read. (Of course, the reading of a well-trained person involves much more than pronouncing one word at a time in response to its written form. Smooth reading with expression is due to the development of these fundamental processes so that they operate smoothly and automatically together with the development of other habits dealing with expression and the like.)

What the teacher must do then is to form a connection between this situation (the word "flag") and the desired response (saying "flag"). This is what she does in the method outlined in Lesson 2, i. e.,

1. Writes sentences on board.
2. Asks for recognition.
3. Demands recall.

This it is clear on a little consideration is the wise course of procedure. For at first the child has no response at all to the written words, "We have a big flag." The white chalk marks on the board mean nothing to the child. They mean, indeed, much less to the child than Chinese symbols do to you, the reader, for the child does not even know that they stand for spoken words—for objects and actions. But the teacher writes the words, "We have a big flag" on the board and pronounces the sentence to the class. Thus a weak link is formed between the sight of the whole sentence and its sound.

Then the child is asked to pick the sentence out from others. This is not so difficult as recalling it would be. We all know it is easier to recognize a face as having been seen before than to give the name belonging to the face. Even a faint connection between situation and response will lead to recognition.

And, of course, every such recognition strengthens the connection. After some drill the teacher can successfully ask what would have been useless before, that is, that the child recall what a given sentence says; i. e., respond to the question, "What does this say?" pointing at the same time to the written sentence. With recall the last step is reached and only more drill is needed. Then the child can read.

Reading is then at bottom, the moving of the muscles of the throat in response to certain curlicues on a page or blackboard. The proper control of these muscles is learned before school age. The joining them up with the new situation, the curlicues, is the task of the teacher of reading.

The object of a school lesson seems then to be the formation of a connection between a given situation and a desired response. An approved primary method is so constituted that it leads naturally from a state in which there is no connection, thru a stage where there is slight con-

nection, and finally to a stage where a fairly strong connection is established and made stronger by drill.

SUMMARY

Two principal points have been made in the course so far. First, you have seen what psychology is and what psychologists are attempting to do. And second, you have been shown that all behavior can be reduced to two very broad conceptions of "situation" and "response."

Hand in at the next class-hour the best definitions you can prepare of the three words, "psychology," "situation" and "response."

OBJECT OF LESSONS 5 TO 20.

With the foregoing statement before us of what a school lesson is aimed to accomplish we are now ready to commence an analytical study of the learning process. Very simple tasks of learning will be assigned and thru careful recording of notes about how the task was accomplished many of the fundamental principles of learning will come to light.

The next class-hour will be devoted to such an experiment. Read over the instructions in Lesson 5 up to the heading: "Instructions for writing up the results." *But do not practice the experiment.* If you do you are quite likely to get results at the next class-hour which will be misleading.

LESSON 5—HOW DOES ONE LEARN TO SAY THE ALPHABET?

The first laboratory assignment in a new course of study must necessarily be very simple, else the beginning student will be swamped with all the details confronting him. Consequently, we shall study here what is apparently a simple problem, i. e., the processes involved in learning the alphabet—particularly in learning to say it backwards. But altho the assignment in one sense is very simple, yet in another sense it is most profound. No one can list all the processes that are involved here nor understand any of them absolutely.

The student commencing this course should carry with him much of the spirit of the early pioneer. He is embarking on a cruise of exploration in which some of the landmarks are known and chartered for him but most of the smaller points of interest are not charted and still remain to be discovered. This course in educational psychology will afford every student many opportunities for discovering facts and principles regarding the learning process not now recorded in any textbook. Consequently attack this seemingly trivial assignment in the spirit of exploration and with the determination to discover new things.

THE EXPERIMENT

1. *Problem.* What happens when you recite (1) the alphabet forwards ten times, and (2) the alphabet backwards ten times?

2. *Apparatus.* A watch with a second hand. (If you do not have such a watch, obtain one from the instructor.)

3. *Procedure.* Two persons will work together; one will be the *subject* (person to do the reciting) and one will be the *experimenter.* When both are ready the Experimenter will watch the second hand and when it reaches 58 on the dial will call out, "Get ready," and when it reaches 60 will say "Go." Subject will then recite the alphabet as fast as possible. When the Subject reaches the letter "Z" the Experimenter notes the number of seconds that have elapsed and records it in his notes. The Experimenter will find it necessary to have before him the alphabet written out so that as the Subject recites he may follow with his eye and note any mistakes in the Subject's recitation.

After each of the 10 trials, the Experimenter should record (a) the time required by the Subject to recite the alphabet, (b) any mistakes in doing so, (c) any changes in method he may note, (d) any other interesting facts.

Having finished the above, repeat the whole procedure but this time recite the alphabet backwards, instead of forwards. The Experimenter should write out the alphabet backwards in order to aid him in catching the mistakes of the Subject. The Experimenter will not prompt the Subject except to say, "No," when the Subject gives a wrong letter.

As before, the Experimenter will record (a) the time required by the Subject to recite the alphabet backwards, (b) any mistakes in doing so, (c) any changes in method, (d) any other interesting facts.

(Finish the above before reading further.)

INSTRUCTIONS FOR WRITING UP THE EXPERIMENT.

If possible both partners should arrange to prepare the assignment together. If this is not possible, then the Subject should secure a copy of the Experimenter's notes. Both should prepare this assignment and hand it in at the next class-hour.

How to plot a learning curve. Refer to the curves shown in Plate I, as a model. In those curves twenty trials are shown, whereas yours will record but ten trials. The curves of no two person are alike, consequently yours will not agree exactly with the two given in Lesson 1.

Plot the data you have secured in the two parts of the experiment. Do as follows:—Secure a sheet of co-ordinate paper. Draw a line across the bottom of the sheet about a half inch from the bottom. Draw another line at right angles to this base line along the left-hand side of the sheet, about a half inch from the edge of the paper. At intervals of

about one-fourth inch number consecutively from 1 to 10 underneath the base line. Number the lines along the vertical line consecutively from 1 up as far as the paper permits. Call the base line "o."
The numbering along the base line represents the successive trials from 1 to 10. The numbering along the vertical axis represents the amount of time consumed in reciting the alphabet. Hence at the right of the figure 10 write the word "Trials" and at the top of the page above the last number in the vertical scale, write the word "Seconds."

When this is done, note the time-record in the first recitation of the alphabet. Suppose this is 6 seconds. Now mark a small "x" at the intersection of the line numbered "6 seconds" and the line numbered "trial 1." Suppose the second trial was done in 5 seconds. Then mark similarly a small "x" at the intersection of the 5-second line and the 2nd-trial line. (If it was 5½ seconds, instead of 5, the cross would be made half-way between the 6-second and the 5-second line.) When you have marked the 10 "xs," then connect them together with straight lines. This jagged line represents the *learning curve* in saying the alphabet forwards. Draw the learning curve for saying the alphabet backwards in the same way.

Give a *title to the sheet,* such as "Learning Curves for Reciting the Alphabet Forwards and Backwards."

How to write up the experiment.

1. The problem. State what is the problem you are attempting to solve. In this case the problem may be stated as "How Does One Learn to Say the Alphabet?"

2. Apparatus: State under this heading what apparatus you used in solving the problem, as "A watch with a second hand."

3. Procedure. State what you did in order to secure your results. Give date and names of the Experimenter and Subject, first of all. In this course you need not copy the procedure as given in the text but may state, "Followed instructions as given in manual, except ——." Then give in detail any deviations.

4. Results. Here record (1) your time records, (2) mistakes made, (3) changes in method, (4) other interesting facts, (5) your curves. In other words, record under this heading the material you have gathered together in performing the experiment.

5. Interpretation. Here ordinarily you would summarize your results and explain what they mean. At the beginning of this course you will be aided in interpretating your results by being given specific questions to answer—questions which help you summarize and explain your results. In this case, answer the following questions:

a. How do your two learning curves differ? Explain why.

b. In what respects do the two curves agree? Explain.

c. Why is it possible to recite the alphabet faster and with fewer mistakes on the tenth trial than on the first trial? Has the Situation changed? Has the Response changed? Has there been any other change which you cannot include under the headings "Situation" and "Response"?

d. Why do you suppose in Lesson 3, Carl could write the word "leaf" on the board after having seen his teacher write it and not before? What changed there—the situation, the response, or some other third thing?

6. Applications. Record concrete cases where principles developed here will apply in other phases of life. For example, in learning to use a saw, one will saw thru a 6-inch plank very slowly the first time and will do a pretty poor job. Next time the job will be done in less time and with fewer ragged edges. Successive trials will result in better and better work. The greatest progress will be made in the early trials.

In this lesson you have probably been confronted with several new things, as follows:

1. Saying the alphabet backwards.
2. A learning curve and its characteristics.
3. Plotting a curve.
4. Writing up the laboratory experiment according to a prescribed outline.

It will require a number of further lessons before the last three of these propositions will become thoroughly established. Apply what you have learned in this experiment to yourself. Do not expect to write up this experiment in one-half the time you will be able to do it in a month from now, nor to do it without many mistakes—mistakes you will not make a month from now. Do the best you can in the time you have for preparing the lesson.

LESSON 6—SOME FACTS CONCERNING THE LEARNING PROCESS AS OBTAINED FROM THE ALPHABET EXPERIMENT*

All learning is dependent upon practice, upon performing what is to be learned. That is the way you originally learned to say the alphabet forwards and that is the only way you can learn to say it backwards.

In like manner you must yourself work out the assignments of the course. And to the extent that you do actually answer the questions, to just that extent you have a real grasp of the contents of the course.

In order to afford you a check upon your work so that you may know how well you are doing it, the even numbered lessons (e. g., lessons 6, 8, 10, etc.) will answer the problems raised in the odd-numbered lessons (e. g., lessons 5, 7, 9, etc.). These answers are not complete answers; no one knows enough today to answer absolutely completely. But they will furnish sufficiently complete answers for the purpose of the course.

It goes without saying that you will secure little from the course if you obtain access to the even-numbered lessons before handing in your written reports upon the corresponding odd-numbered lessons.

ANSWERS TO QUESTIONS IN LESSON 5.

How do your two learning curves differ? Explain why.

1. The "saying alphabet forwards" curve drops very little, whereas the other curve drops a great deal. That is, there is very little improvement in the first case and a great deal in the second.

2. The curve in the first case is practically a straight line (disregarding now the irregular fluctuations) while the curve in the second case shows a very great drop at first with less and less of a drop as the trials continue.

3. The second curve is thruout "higher" than the first curve.

Explanation. The learning curve of a performance that has not been practised, always shows a big drop after each trial, but as the trials continue, the curve drops less and less until it finally reaches a certain limit. In the case of saying the alphabet forwards we must realize that the early trials (with their resulting big drops) have oc-

*CLASS-HOUR	IN CLASS	WRITE-UP	READ
6	Discuss, 5		Lesson 6
7	Experiment, 7	Lesson 7	

curred long ago. We are dealing possibly with trials 1001 to 1010 and can expect only very slight improvement from trial to trial. In fact we must be fairly near the limit of speed that can be obtained in this performance.

The chief difference between the two curves is to be explained by the fact that the first curve is the only portion we have of a learning curve made up of, say, a thousand and ten repetitions, whereas the second curve is actually representative of the beginning of a learning process. The first curve must needs be nearly a straight line with only a slight drop, while the second curve must needs show large drops between each successive trial, but smaller and smaller drops as the repetitions continue. If we kept up the reciting of the alphabet backwards 10 times a day for a month or more possibly we would then get a curve on the last day that would be similar to our first curve.

From the shape of the curve we can then tell something as to the amount of training which has already preceded the first trial shown in the curve.

In what respects do the two curves agree? Explain.

1. Both drop. Both show improvement in the work done.

Explanation. A fundamental law of human behavior is the only explanation that can be given for the fact that both curves drop. Continued repetition of a performance results in that performance becoming easier and easier and when there is any effort made to decrease the time of doing it, the performance is done in less and less time.

2. Both show fluctuations. Improvement is not always shown between successive trials. Sometimes the performance is much inferior to that of several preceding trials.

Explanation. The performance of any act is made up of many parts. Learning the whole performance (e. g., saying the alphabet backwards) consists in learning to do each little part and in learning to do them in the correct order. Sometimes the parts are all fairly well done—then we make a better record than usual,—there is a sudden drop in the curve. Sometimes the parts are done poorly—then we make a poorer record than usual—there is an upward shoot to the curve. Most of the time we do some parts well and some poorly—then we make an average record.

The causes as to why any part is done poorly or well will be taken up later. (Commence watching for them. Note why you fumble in tying your shoes, putting on your hat, shaving, spreading butter on a slice of bread, misspelling a word, answering a question incorrectly in an examination, etc.)

In what respects do the situations and responses differ at the beginning and end of the two experiments? Explain why. (This question is inserted in addition to those asked in Lesson 5.)

As to situation.

1. Certain details were added to the situation. Certain details affected the Subject more and more, e. g.,
   a. Certain combinations of letters are difficult (e. g., w. v. u. t.) and so are watched with more than ordinary care.
   b. Letters said at first more or less one at a time, later become grouped,—groups thus take the place of single letters as the items which affect the subject .
   c. "Idea you must go fast," "Idea you must not make mistakes," etc.

2. Certain details were eliminated more or less from the situation, e. g.,—
   a. Strangeness of surroundings ceased to affect the Subject.
   b. Strangeness of requirement,—to recite alphabet in psychology class,—was forgotten.
   c. Presence of other individuals, their conversation, etc. became less noticeable.
   d. Presence of the Experimentor, the fact that he was watching, the fact that he was taking notes, the fact that he was timing, etc., had less effect.

3. In other words, as learning progressed, the situation actually changed. Certain details affected the Subject more and more and certain other details less and less.

As to Response.

1. Actual performance was done (a) more quickly, (b) with fewer mistakes, (c) more smoothly.

2. Feelings of strangeness, unfamiliarity, nervousness, excitement, unpleasantness, etc., became changed more or less to feelings of familiarity, confidence and pleasantness, etc.

3. Actual method of doing work was changed, particularly in saying alphabet backwards, e. g.—
   a. At first alphabet had to be recited forwards in order to say it backwards; later this became unnecessary.
   b. It was recited in short pieces with pauses in between.
   c. Pauses became shorter, groupings of letters longer and longer.
   d. Etc.

The process of learning involves then not simply doing work faster and faster with fewer and fewer mistakes, but also attention to different details in the situation coupled with qualitative changes in method.

Why is it possible to recite the alphabet faster and with fewer mistakes on the tenth trial than on the first trial? Has the situation changed? Has the response changed? Has there been any other change?

The first part of this question has been answered under the second question, above.

Has the situation changed? In one sense, No. There are the same factors outside the learner at the tenth trial that were there at the first trial. But in another sense, Yes. In some way or other the learner has changed, so that he is influenced less by certain of the outside factors and more by other outside factors. Actually from the standpoint of the learner, then, the situation has changed, he is affected by details in a different way from what he was at the start.

Has the response changed? Undoubtedly. This is shown by the decrease in time and the increase in accuracy, also by the change in attitude toward the task.

What other changes have there been? We shall come to see that the mechanism within the learner that is affected by outside factors and that controls the learner's muscles (for all behavior is composed of muscular movements) has been changed. This mechanism is the nervous system of the learner. It has in some way or other been changed by the repetition of the alphabet.

We may think of this nervous mechanism as having been changed, on the one hand, so that now in this particular situation it is more susceptible to certain details and less susceptible to other details, and on the other hand, that it controls and directs the muscles engaged in speaking differently from what it did at the start. The learner is certainly more susceptible to the difficulties of reciting "w,v,u,t," than at the start. He is also less concerned with the presence of his partner than at the start, and undoubtedly does recite the alphabet backwards in a much better manner than at the start. His behavior is different. His response to the situation is different.

It is clear from what has gone before that we shall need to add to our conceptions, "situation" and "response" a third conception—a conception to cover the linkage of the situation to the response. The situation comprises those details that affect or stimulate the learner's sense-organs (eye, ear, skin, etc.) and the response comprises those movements that make up the total behavior which results from the situation. Connecting the stimulated sense-organ with the moving muscles are nerve-cells and nerve-fibres. For the present let us speak of this nervous connection as the *"bond"* or "connection." We may then look upon the learning of the alphabet as comprising a certain situation, a certain re-

sponse and a bond between the two. At the start this bond is very imperfectly developed. As repetition continues, the bond is developed until finally the situation (Experimentor says, "recite the alphabet backwards") is adequately bound to the various muscular movements which cause the letters of the alphabet to be sounded.

Let us look upon the multiplication table in this same way. The teacher asks, "What is 6 times 8?" The child responds "48." The situation, in terms of the child, is (1) the teacher, (2) the sounds making up "What is 6 times 8?" Certain muscles in the throat and mouth move and the child has said "48." Connecting the ear and the throat muscles are various nerve-centers and nerve-fibres. The stimulation in the ear has been communicated in a wonderful way over these nerve-pathways to the muscles in the throat and they have been moved—and "48" was said. The terms, "Situation," "Bond," and "Response," may be thought of now as covering this whole learned performance.

Why do you suppose Carl in Lesson 3 could write the word "leaf" on the board after seeing his teacher write it and not before? What changed there—the situation, the response or some other third thing?

If Carl has learned to write the word without knowing his letters, then the sight of the word and sound of the word have both become bound up with the movements of making the word. While Carl looked at the word and while he listened to the sound of the word, he wrote the word in the air, i. e., made the movements necessary to write the word. Diagrammatically, we have

Sight of word ——→ Movements involved in writing word.
Sound of word ——→ Movements involved in writing word.

Thru previous training in school and outside Carl had learned how to trace a drawing. Hence when he saw the word he was able to trace the word in the air. After a sufficient number of repetitions the bond connecting this situation with this response becomes strong enough to function. But the possession of a bond between *seeing* the word "leaf" and writing it is not enough, else Carl could not write the word when his teacher *pronounces* it. While Carl was looking at the word he was also muttering it to himself. The teacher was also pronouncing it. Hearing the word then was part of the situation. And while hearing it he was also writing it in the air. Repetition of this detail of the situation and the response shortly results in a bond being formed between hearing the word and writing it.

To answer the question, we must reply that a bond was formed between sight of the word "leaf" and the movements necessary to write it, also a bond between hearing the word and writing it. There has been a development of new bonds and consequently a new response.

Before there was no bond and hence no writing response to the word "leaf." Afterwards there is a bond and so an appropriate response is possible.

It should be borne in mind that the above analysis is not so full as it should be. And it should further be borne in mind that this analysis may be true of some children and not true of others. We do not know today just how all children come to do these things. Future details will be added as this course develops.

SUMMARY OF POINTS COVERED SO FAR IN THIS COURSE

1. Demonstration of sight spelling lesson.
2. Understanding of the terms, "Situation," "Bond," and "Response."
3. Realization that a situation is a complex affair made up of many details and a response is correspondingly complex.
4. Method of plotting a learning curve.
5. The fact that repetition of the same performance produces changes in the *real* situation, in the response, and in the bonds connecting situation with response.
6. Some characteristics of learning curves.
7. A method of writing up a laboratory exercise, involving the classification of your material under six headings:—
   a. The Problem, what you are trying to do.
   b. The Apparatus, what you have to work with.
   c. The Procedure, how you go at solving the problem.
   d. The Results, what information you discover.
   e. The Interpretation, what you decide the results mean.
   f. The Application, how the general principles outlined under "Interpretation" can be applied to other problems.

LESSON 7—HOW DOES ONE IMPROVE AS ONE LEARNS TO DRAW IN THE MIRROR-DRAWING APPARATUS?

In Lessons 5 and 6 we obtained some idea of the process by which one learns an alphabet. The same general principles will apply more or less to the learning of lists of things, such as conjugations, declensions, etc.

Today we are interested in discovering the general characteristics of the learning process in such cases as learning to write with a pen, to ride a bicycle, to skate, to use a saw, etc. As adults are all able to write it is manifestly impossible to study with adult subjects the learning processes involved in handwriting. For that reason the experiment will be devoted to learning to draw while looking in a mirror. This process

involves many factors which are common to learning handwriting. Endeavor as best you can to understand this learning process as it will help you to understand what a child experiences while learning.

As before, one partner will act as Experimentor (E) and the other as Subject (S). Here the emphasis will be upon completing the drawing of 17 stars in the mirror-drawing apparatus. This can only be done by prompt and efficient effort.

THE MIRROR-DRAWING EXPERIMENT.

Problem: How does one improve as one learns to draw in the Mirror-Drawing apparatus?

Apparatus: Mirror-Drawing Outfit; 17 six-pointed star blanks, watch.

Procedure:

(1.) The Experimentor determines how long it takes the Subject to trace the outline of the star, *without using the mirror.* Let him start at the point marked in the star and draw naturally around within the two lines.

(2.) Experimentor arranges the apparatus so that Subject can not see his own hand directly, but only thru the mirror. Subject is to trace the outline of the star as quickly as possible with a lead pencil.

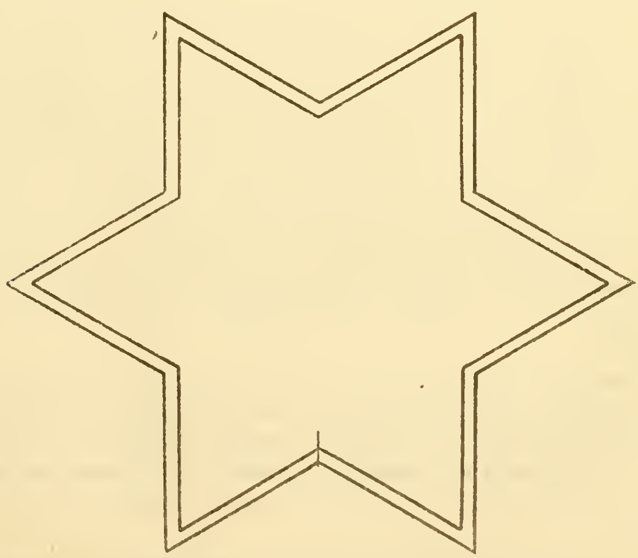


Plate 11. Star blank for mirror-drawing experiment.
(Actual size 4 1/4 x 5 inches.)

The requirement is that the pencil *must stay on the paper*, and must pass in order around the star. Measure the time required to pass around the star. Then record the number of times the pencil line touches either of the two printed lines. Each one should be counted a mistake. Furthermore, when the pencil is outside of the two printed lines, each change in direction should also be counted as one mistake.

The star should be so placed that the starting point is towards S as he sees it in the mirror. If now each point is numbered from 1 to 12 (12 being at the starting and ending point and 1 at the point to S's right as he sees it in the mirror), it will be found to make the matter of writing up the laboratory notes much easier, for all places on the star can thus be easily referred to.

Be sure to write on each star-blank the number of the trial and the name of the Subject, also the time consumed in doing the drawing. Otherwise a gust of wind may mix up your papers and ruin your experiment.

(3.) Have S trace 14 more stars in the mirror-drawing apparatus, making a total of 15 in all. Obtain the time for each trial.

(4.) Have S trace another star as he did in (1) without the use of the mirror.

This provides for the use of 17 star blanks; 2 are used without the mirror and 15 with the mirror.

Results: E should have recorded then, (1) the time of each performance, and (2) the number of false moves to be observed by counting the number of times the lead pencil touches or crosses a printed line, and the changes in direction when without the printed line.

The learning curves. Plot both the time-records and the accuracy-records. Provide on the base line space for 17 trials; on the vertical axis space for recording up to 300 seconds. (You can do this by letting each horizontal line represent 5 or 10 seconds.) Remember trials 1 and 17 were made without the mirror; trials 2 to 16, with the mirror. Do not connect trials 1 with 2 or 16 with 17. Connect trials 2 with 3 with 4, etc., up to 16, using a solid line; and trial 1 with 17 using a dotted line.

Next plot the accuracy-records. For the sake of convenience consider each error equivalent to a second in time and plot accordingly. Finally plot a third curve obtained by adding together the seconds taken to do the trials with the number of errors. This curve will represent the course of learning, taking into account both time and accuracy combined.

Both partners will write up the report according to the outline given in Lesson 5. The *Results* will include the material *(data)* gathered

together duing the experiment and also the three learning curves. Under the heading *"Interpretation"* note answers to the following questions:

1. What changes take place when the same performance is repeated a number of times? Consider (a) speed, (b) accuracy, and (c) the two combined.

2. What light do the data, secured when the mirror is not used, throw upon the main results of this experiment? In other words, how efficiently do you suppose the Subject could come to do the mirror-drawing after a great deal of practice?

Do not fail to report under the heading *"Applications"* some *concrete* examples of how the principles discovered in the experiment, can be applied to your own work.

NOTES: (1) The word "data" is plural always.
(2) As you are studying the learning process it is absolutely essential that S shall not practice in any way whatever between trials, else your data will not be complete. If a trial is performed and the time-record is lost, report this fact. For example, if the time-record for the 12th trial was lost, call it nevertheless the 12th trial, and the next trial the 13th. In plotting, simply connect the 11th and 13th records with a dotted line, to indicate that the 12th record is missing.

LESSON 8—GENERAL CHARACTERISTICS OF THE LEARNING PROCESS.*

ANSWERS TO THE QUESTIONS IN LESSON 7.

What changes take place when the same performance is repeated a number of times? Consider (*a*) *speed,* (*b*) *accuracy, and* (*c*) *the two combined.*

The first drawing with the right hand in the mirror was done very slowly and with many mistakes. The second drawing was very much better, there being a noticeable decrease both in the time consumed and the number of mistakes made. With each subsequent trial there was improvement (barring certain exceptions) until with the last trial we have a drawing made in very much less time and with few errors. In Plate III we have three learning curves showing 20 trials (not 15) and based on the average of 18 records from men and women. Both curves A (accuracy) and B (speed) show rapid improvement at the start with smaller and smaller gains as the practice continues. The combined curve (C) shows the same peculiarities.

From studying curves B and C it is apparent that if these 18 individuals had continued the practice for more than 20 trials they would have improved still more. Curve A, on the other hand, suggests that they had reached their limit in accuracy; in fact, that they had reached this limit by about the 8th trial. (Trials 12 and 18 being actually the most accurate.) There is, however, another possible explanation. The instruction given the individuals whose average data we have before us, was purposely left indefinite as to whether *speed* or *accuracy* should be striven for. Their reports show, however, that most of them had in mind doing the task as quickly as possible, having in mind a fair degree of accuracy, rather than doing the task as accurately as possible with a fair degree of speed. Consequently, the time curve shows the greater amount of improvement. It is extremely likely then that the accuracy shown in Curve A from the 8th to 20th trials represents to these individuals "a fair degree of accuracy,"—that during those trials there was little or no attempt to improve their accuracy. If this be true, further practice would eventually bring each subject to a point

*CLASS-HOUR	IN CLASS	WRITE-UP	READ
8	Discuss, 7		Lesson 8
9	Review, 1-8		Lessons 1-9
10	Examination		Lesson 10
11	Experiment, 11	Lesson 11	

where he would realize that his accuracy-record was not so good as it might be as compared with his time-record. His general attitude toward the work would change then so that he would strive for accuracy in a way that he had not done previously. Following this change in attitude there would undoubtedly appear a series of drops in the accuracy-curve with possibly little or no improvement in the time-curve. Judging then from what we can learn from the observations of our subjects, they have not reached their limit of improvement in accuracy, but rather only a temporary limit, this temporary limit being due to their attitude toward the work.

Errors (A), Seconds (B), The two added (C).

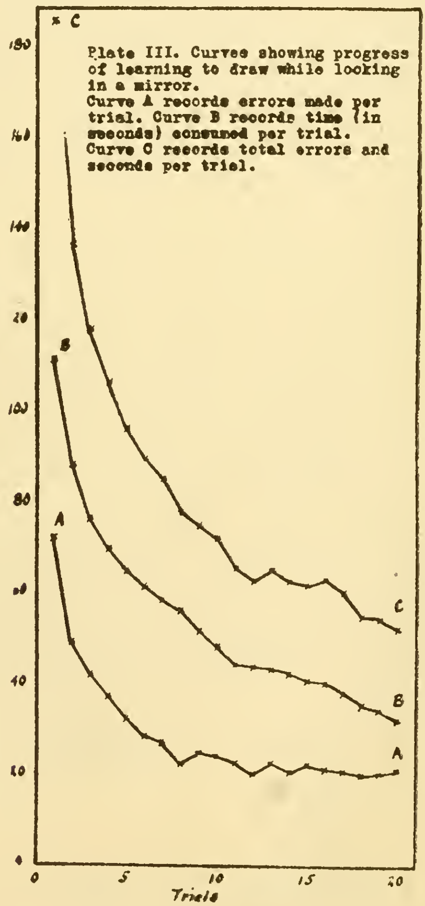


Plate III. Curves showing progress of learning to draw while looking in a mirror.
Curve A records errors made per trial. Curve B records time (in seconds) consumed per trial.
Curve C records total errors and seconds per trial.

Such temporary limits are called *plateaus* or level places in a learning curve. In terms of what little we now know from this course about plateaus, we may define them as "temporary limits to improvement." In terms of our three terms, Situation, Bond, and Response, we may say that certain details in the situation are not affecting the learner as they should. Because they are not, there is little or no response to them and hence no improvement in the bonds connecting those details in the situation with their appropriate details in the response. Later these details commence to affect the learner, the bonds between those details and their responses commence to be used and improvement follows. At least this was apparently the case here. The little irregularities in the drawn line together with various memories which make up our notion of accuracy, all these were not affecting the learner so strongly as they might. As these details were being reacted to only a little or not at all there was little or no chance for the bonds to be developed. Later these same details would commence to affect the learner and then there would come improvement in accuracy.

We shall then need to add to our previous conceptions of a learning curve—rapid improvement at first with less and less improvement as time goes on—this notion of a *plateau*. Improvement may cease entirely, certainly as far as objective proof is concerned, for a period of time and then commence again. (Later on in this course we shall go into this subject of plateaus and endeavor to ascertain in more detail the causes of their appearance.)

The plateau may be looked upon as a peculiar kind of fluctuation or deviation from the true course of learning. It is a deviation which extends over a number of trials. The most common form of deviation is that which occurs very frequently in practically all learning curves and consists in sudden up or down deviations from the general trend of the curve. In Plate III, Curve A, we have such downward fluctuations at the 8th, 12th, 14th, etc., trials, and an upward fluctuation at the 7th trial. But these fluctuations are much less frequent and much less prominent in Plate III than they are in curves plotted from the data of just one individual. These fluctuations from trial to trial have already been referred to in Lesson 6, where an explanation of their cause is given.

What light do the data secured when the mirror is not used throw upon the main result of this experiment?

The data secured when the mirror is not used give us a clear idea of just how fast and accurately the subject can do the drawing without the mirror. The efficiency shown measures the strength of the old bonds formed in drawing, writing, etc., which function here. There is no

reason to suppose that with sufficient practice the subject could not reach this efficiency under the new experimental condition. These data then give us some idea of the possible limit to the learning curve obtained in our twenty trials. But it is true that further practice without the mirror would lead one to draw the star in less time and more accurately. Consequently even this determination obtained without the mirror is not low enough for the final limit that might be reached by a vast amount of practice in the mirror. The final limit that an individual might reach with unlimited practice is called the *physiological limit* to the learning. It means that the physiological processes involved in the performance require a certain time and that when one reaches this limit one cannot progress further. It is extremely unlikely that the ordinary individual ever reaches his physiological limit in more than a very few simple processes which he has practiced vigorously a great many times. In most things we are very far from the limit.

The plateau, referred to above, may be thought of, then, as a *temporary limit* in distinction to the *physiological limit* which is the final permanent limit of progress.

What applications can you make of the principles you have discovered to your own work?

Knowledge as to how fast a child of a certain age could possibly add columns of figures (physiological limit) would be helpful in handling him, especially when his work shows that he is on a plateau. By this we do not mean that our ideal is to have a child even approximately attain his physiological limit. Far from it. But it would help keep us from fearing to overstrain the boy when what he needs is to be urged to do his best.

Miss K. Anthony reports a case of an exceedingly bright boy who was but 9 years old but had been advanced to the 6th Grade. He stood at the head of his class in all matters of originality, initiative, and clear thinking but near the bottom in speed of handwriting, in drawing, and manual work. She believes his inability to do these latter performances as well as the average member of the class is due to his immaturity. An 11 or 12 year old boy is physically stronger and more dexterous than a 9 year old boy, just because he is two or three years older. And this difference is great enough so that a 9 year old bright boy is seriously handicapped in competing with an average 12 year old. If Miss Anthony's conception is correct, i. e., that her 9 year old boy is doing poor work in manual training just because he is too young, then there need be no worry about his poor performance. He is doing as well as can be expected of a 9 year old, altho it is not 6th Grade work.

But if she is wrong and he does poor work because he is not interested or not gifted along these lines, then extra effort should be put forth to get him to do better. An exact knowledge of what different aged boys could do and what they naturally do do in manual training would help her here in determining how to handle him.

Miss Mary L. McGahey found it impossible to improve Carl's arithmetic work as to speed. He was a 6th Grade pupil and did good work but did not solve simple arithmetical problems as fast as he should. The fact that Miss McGahey knew that his rate of work was much below what an average boy could do made her realize that Carl was on a plateau which was far from being his physiological limit. This made her realize that something was wrong and that it "was up to her" to find it. Finally she noticed that he tapped twice before commencing to solve the simple combinations as

$\begin{array}{r}4\\2\\\hline\end{array}$, $\begin{array}{r}8\\3\\\hline\end{array}$, $\begin{array}{r}7\\1\\\hline\end{array}$, $\begin{array}{r}4\\0\\\hline\end{array}$, etc. On calling his attention to the matter and then reproving him every time he did tap, she quickly broke him of the habit. As a result he increased his rate of work by 50% in a few hours' time. If Miss McGahey had not known (1) what a child of Carl's age ought to do and (2) that he was making no progress, she would probably have never discovered the tapping and so never have trained him to do arithmetic problems at an efficient rate. (The tapping is undoubtedly a survival of an earlier habit of counting by making dashes on paper, instead of with one's fingers. Apparently Carl on finishing writing 6 as the answer of $\begin{array}{r}4\\2\\\hline\end{array}$ had to tap twice before commencing to think what $\begin{array}{r}8\\3\\\hline\end{array}$ meant. Under such a method he had pretty nearly reached his physiological limit. When the tapping was eliminated then he was able to think the answer 11 to $\begin{array}{r}8\\3\\\hline\end{array}$ while writing the 6 and so could write continuously the answers to these problems, working out the answers ahead of where he was writing.)*

*Kate Anthony, Mary L. McGahey, Edward K. Strong, Jr. The Development of Proper Attitudes Toward School Work. School and Society, Dec. 25, 1915, II., 926-934.

LESSON 9—GENERAL REVIEW

Instead of laboratory work at the next class hour (9th Lesson), opportunity will be furnished the members of the various sections to meet with their instructor and clear up any points so far covered which are not yet clear.

REVIEW

Behavior, we have come to see, can be broken up into three major conceptions: The *Situation,* (the sum total of all the elements affecting the individual), the *Response* (the sum total of all the muscular movements resulting from the effect of the situation) and the *Bond* (the specific nerve connections between the sense-organs affected by the situation and the muscles involved in the response).

Learning consists in the formation of bonds (nerve connections) between situations and the appropriate responses.

The *Laws of learning* are the laws as to the formation of bonds. We have become familiar already with several of these laws. For example: there is rapid improvement at first with less and less improvement as practice continues; improvement is never continuous—there are always fluctuations in the curve of learning; under certain conditions plateaus develop—periods of no apparent improvement; and there is a limit to improvement (physiological limit) beyond which we can not go, but which is practically never reached due to lack of sufficiently strenuous practice.

DIFFERENT TYPES OF LEARNING.

In the case of reciting the alphabet forwards an individual utilizes (1) already well developed bonds governing the pronunciation of the twenty-six letters, and (2) bonds governing the succession of individual bonds. To make this point clearer, suppose the Experiment had called for ten recitations of the Russian alphabet. In that case you would not have known the letters at all nor their pronunciation and moreover you would not have known their order of succession. In the experiment with the English alphabet, the command "recite alphabet" starts a long series of responses each of which is connected with the succeeding one by a bond, i. e.,

Situation	*Response*
1. "Recite alphabet"	saying "a"
2. (1) and saying "a"	saying "b"
3. (1), (2) and saying "b"	saying "c"
etc.	

As each letter is pronounced it becomes a part of the situation to which we react in pronouncing the next letter. The original situation

"Recite Alphabet" also remains a part of the situation thruout. If it did not one would be likely to stop reciting or wander off onto other things.

As an opposite extreme to this case, imagine an experiment in which you were called on to wiggle your ears. You would be unable to do it at first because you have no bonds at all between the situation ("wiggle your ears") and the response (contracting the muscles which move your ears.) Here the only way in the world you can learn to gain control of this bond is by trying all sorts of movements in the hope that eventually you will hit upon the proper one, i. e., the moving of your ears.

In the case of reciting the alphabet forwards, you make only appropriate movements with slight mistakes from time to time (fluctuations). In the case of wiggling your ears, you make inappropriate movements with occasionally the correct movement. This second type of learning is called *"trial and error,"* as it is characterized primarily by many trials and many errors.

We can classify different types of learning according to the following elements.

1. Necessary Bonds exist.	Order of succession of bonds known.
2. Necessary Bonds exist.	Order of succession not known. a. Order is calculated. b. Order is not calculated.
3. Necessary Bonds do not exist.	Order of succession, therefore, not known. a. Order is calculated. b. Order is not calculated.

"Reciting the alphabet forwards" is typical of type 1. The specific elements all exist and their exact order of succession is also known. Further practice results in improvement in the performance, but the improvement is relatively slight. It is customary to think of such further practice as *"drill"* rather than "learning." So after the multiplication table is known, i. e., each element is known (situation "6 times 7," response "42") and the order of the groups is known, we call further practice "drill work" not learning.

"Reciting the alphabet backwards" is typical of type 2a. We know the individual elements (saying the letters) but we do not know the order of succession (z, y, x, w, etc.) But we can silently recite the alphabet forwards until we come to "w, x, y, z," then hold these four letters in mind and recite "z, y, x, w"; then recite forwards again until we reach "s, t, u, v," then recite aloud "v, u, t, s," etc. Continued practice as we have seen, will shortly make unnecessary the forward recitations. In

this way the task of reciting the alphabet backwards is gradually transferred from class 2a to class 1.

Solving the usual mechanical puzzle is typical of type 2b. Here we are able to make all the necessary movements but we do not know which ones to make; and the puzzle actually consists in discovering the necessary movements and their proper order. Before we have discovered this order we may have made all of the necessary movements many times but always in an incorrect order.

The mirror-drawing is typical of type 3a. The necessary bonds do not exist, but we see immediately whether we are going in the right direction—hence the order is in a sense given us. Looking in the mirror upsets our usual set of bonds for the guidance of the hand in drawing. Usually when we wish to draw a line towards our body we make certain movements; now we find that these do not bring the hand, as we see it in the mirror, towards the body. We must make new movements. At first we do not know what to do. Gradually, however, out of the many movements performed by us, we make the correct movements more and more often. Eventually a bond is formed between "situation—follow between two printed lines towards our body as seen in the mirror"—and the response to actually move our hand away from the body. Gradually, then, after considerable practice the mirror-drawing task changes over from type 3a to 1.

Learning to wiggle one's ears, as has already been pointed out, is an example of the most extreme type of learning, for here we do not know what movements to make nor do we know from watching our own performance when we have really made the movement we have seen another boy make. For sometimes we move our ears but also our whole scalp or the side of our face. The latter element we do not want. Have we moved our scalp or the side of our face and only incidentally our ears, or have we actually moved our ears and shall we, with further practice in this way be able to eliminate the scalp or face movement? We have no way of telling. Consequently we keep trying and trying and finally accomplish our purpose, or in most cases, we give it up as a bad job.

Learning the characteristics of the learning process, as you are doing in this course, can be made by any particular author to fit any one of these types of learning. He can supply you with every detail in one, two, three order and expect you to memorize the material and thru drill have you recite it as glibly as you do the alphabet. Or he can assign very indefinite problems and leave you to discover the elements and their order of relationship (type 3b). The former, however, will not result in your obtaining a workable use of the material: the later will

take too long and is too discouraging, altho if you do learn this way you have a wonderful grasp of the subject. Consequently, the present author prefers to present the material in the experiments in the form of types 2 or 3, followed, as in this lesson, with a discussion of the material, so that missing bonds may be identified and learned and their relationships to one another comprehended and also learned. The material in this lesson is not given to be memorized; it is given as a guide, just as the printed lines in the mirror-drawing were a guide, so that you may have a better idea of where you are going and how the different parts of the course fit together.

LESSON 10—EXAMINATION COVERING THE WORK OF THE COURSE SO FAR

The 10th class-hour will be devoted to a general examination covering the work of the whole course.

ASSIGNMENT OF WORK TO BE HANDED IN AT THE 11TH CLASS-HOUR.

1. Spend one hour and a half in looking over one or more of the following standard textbooks in psychology and in writing about three hundred words concerning what you got out of this assignment. The assignment is mainly for the purpose of acquainting you with such textbooks so that you may come to know where to turn when you want to look up a topic in psychology. The textbooks are:—

J. R. Angell, *Psychology,* 1909.
J. R. Angell. *An Introduction to Psychology,* 1918.
B. B. Breese, *Psychology,* 1917.
M. W. Calkins, *A First Book in Psychology,* 1910.
M. W. Calkins, *Introduction to Psychology,* 1902.
S. S. Colvin and W. C. Bagley, *Human Behavior,* 1913.
S. S. Colvin, *The Learning Process,* 1911.
K. Dunlap, *A System of Psychology,* 1912.
H. Ebbinghans, *Psychology,* trans. by M. Meyer, 1908.
F. N. Freeman, *How Children Learn,* 1917.
K. Gordon, *Educational Psychology,* 1917.
Wm. James, *Psychology, Briefer Course,* 1892.
Wm. James, *Psychology,* 2 vols. 1890.
C. H. Judd, *Psychology, General Introduction,* 1907.
G. T. Ladd & R. S. Woodworth, *Physiological Psychology,* 1911.
Max Meyer, *Fundamental Laws of Human Behavior,* 1911.
W. B. Pillsbury, *The Essentials of Psychology,* 1911.
W. B. Pillsbury, *The Fundamentals of Psychology,* 1916.
C. E. Seashore, *Elementary Experiments in Psychology,* 1908.

E. L. Thorndike, *Elements of Psychology,* 1905.
E. L. Thorndike, *Educational Psychology, Briefer Course,* 1914.
E. L. Thorndike, *Educational Psychology,* 3 vol. 1913.
E. B. Titchener, *Outlines of Psychology,* 1896.
E. B. Titchener, *Textbook of Psychology,* 1912.
E. B. Titchener, *Beginners' Psychology,* 1915.
J. B. Watson, *Behavior,* 1914.

2. Read over the details listed below regarding the construction of learning curves. They are not to be memorized, but should be frequently referred to until they have all been mastered. It will take some time before you will draw curves readily and correctly. In this scientific age no one can call himself educated who does not know how to use this method of expressing complex ideas. Once you have mastered the intricacies of this new "language" you will be astonished to find how often you make use of it. Place before you the model graph given in Plate I, Lesson 1, and note how the rules given here are exemplified in it.

SOME INFORMATION CONCERNING THE CONSTRUCTION OF LEARNING CURVES.

1. All learning curves are based on two columns of data. The first column indicates the successive trials or successive units of time in terms of which the progress of learning is measured. The second column gives the measurements of the learning. For example, the data on which Curve B in Plate I is based are as follows:—

Trials	Number of Seconds Required to Recite the Alphabet Backwards.
1	46.0
2	30.1
3	28.4
4	27.8
5	25.1
6	22.9
7	21.0
8	21.8
9	21.2
10	20.1
11	20.2
12	16.9
13	18.2
14	16.0
15	15.3
16	15.6
17	13.6
18	13.9
19	15.5
20	12.5

2. The trials are indicated along the horizontal axis and the "measurements of the learning" along the vertical axis.

3. Figures for the horizontal scale should always be placed at the bottom of the chart and the figures for the vertical scale at the left. Make clear what the scales mean.

4. In the curves in the psychological field, the horizontal scale should read from left to right and the vertical scale from bottom to top.

5. All lettering and all figures on a chart should be placed so as to be read from the base or from the right-hand edge of the chart.

6. Points on the curve should be indicated with little crosses (x) and connected with a line that is heavier than the co-ordinate ruling so that the curves may be clearly distinguished from the background.

7. Only in exceptional cases should the zero line of the scale be omitted. If it would require too much space to include the zero base line, the bottom should be a slightly wavy line indicating that the field has been broken off and does not reach to zero. This is shown in the accompanying graph, Plate IV.

8. The title of a chart should be so complete and so clear that misinterpretation will be impossible. In fact, the ideal is to write so definitely that if a stranger picked up the chart he could understand what it meant.*

*A good references on this subject for those interested in the subject is: W. C. Brinton, Graphic Methods for Presenting Facts.

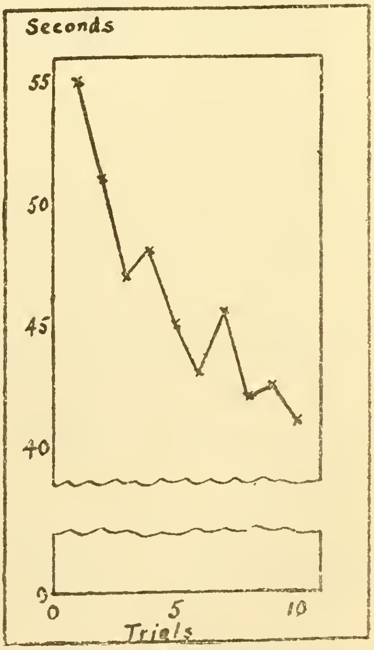


Plate IV. Model graph, showing how zero base line should be indicated when there is not space available to include base line.

LESSON 11—THE RELATIONSHIP OF "METHOD," "ATTITUDE" AND "FEELING" TO LEARNING

Some of the more obvious laws of learning have been presented. We are now ready to attempt a more careful study of less apparent factors.

What happens when we change our method of doing a certain task—say of playing golf, of going from the sight to touch method in typewriting, or discovering a new way to solve originals in geometry? Do our feelings affect our work? We think they do: but do they really do so? Does the man that is confident do better than the man that is fearful? If so, why?

MIRROR-DRAWING EXPERIMENT (repeated)

Problem: What factors are involved in learning Mirror-Drawing?

Apparatus: Mirrow-Drawing Outfit; 10 six-pointed star blanks; watch.

Procedure: E should here be the S of the 7th class-hour and S the E of that exercise. Follow the general procedure of the 7th class-hour, but here S should only draw with the right hand in the mirror.

The emphasis is *not upon completing* 10 drawings *but upon obtaining as detailed an idea* of how one learns as is possible. Consequently after each drawing, S should note down every fact that occurs to him regarding his method of doing the work, the ideas that came to him while doing the drawing, his attitude toward the work, his feelings, etc. E should also record changes in *method* which he notes in S, changes in *feeling* or *attitude* toward the work, etc. Note down, for example, every sigh or exclamation of impatience, and ascertain if there is any relation between its occurrence and success or failure.

Results: E should have recorded, (1) the time of each performance, (2) the number of errors in each drawing, and (3) the observations of both S and E accompanying each performance.

Draw three curves as in the 7th class-hour experiment.

Questions:

1. What changes take place when the same performance is repeated a number of times? Consider (a) differences in method or "mode of attack," (b) differences in attitude toward the work, (c) differences in feeling and emotion.

2. How do such changes affect the changes in speed and accuracy?

3. How are improvements hit upon? Were they (a) accidental, (b) partly understood, or (c) thoroughly understood beforehand?

Applications: What applications can you make of the laws you have discovered here to your work?

Write up this experiment and hand it in at the next class-hour.

LESSON 12—RELATIONSHIP OF "METHOD," "ATTITUDE" AND "FEELING" TO "LEARNING"*

(Continued)

WHAT CHANGES TAKE PLACE WHEN THE SAME PERFORMANCE IS REPEATED A NUMBER OF TIMES.

a. *Differences in method or "mode of attack."* There are a number of different methods of doing the mirror-drawing. Most individuals learn thru trying this thing and then that. Here and there is an individual who utilizes his knowledge of physics and figures out how his movements should be made. But in even these cases there is considerable of the "try this, try that" performance. Then again, most individuals direct the movement very largely by the eye. But occasionally an individual initiates each new movement in terms of the relationship of his pencil to his little finger. If he desires to move toward his little finger (determined thru vision) he then moves his forefinger and thumb toward his little finger—the guidance being in terms of finger-movements not in terms of vision. The eye is used in this case simply to record the general direction desired and to guide the pencil between the two red lines.

As practice continues the individual may steadily improve on the details of his procedure or he may from time to time try other methods. In the latter case he may return to his first method or he may abandon it entirely. There is no general rule to be laid down as to the course of these changes. Each individual should, however, endeavor to ascertain as accurately as he may just what changes did take place in his own case.

b. *Differences in attitude toward the work.* Ruger** calls attention to three different general attitudes toward one's work. He calls them (1) the self-attentive attitude, (2) the suggestible attitude, and (3) the problem attitude.

The *self-attentive attitude* is illustrated by him by this extract from a man's account of how he solved a puzzle. "It seemed to me that if anybody had given it to me without saying that it was a puzzle (a bona fide one) I would have said it was impossible up to the last minute. I have a feeling now of loss of esteem. I had this all along because I couldn't do something which was made for people with ordinary brains

**H. A. Ruger, The Psychology of Efficiency, 1910, pp. 36-39.

*CLASS-HOUR	IN CLASS	WRITE UP	READ
12	Discuss, 11		Lesson 12
13	Experiment, 13	Lesson 13	

to do. One conclusion that kept running through my mind all the time was that I had a subordinate mind. I couldn't help having a gleeful, self-satisfied feeling when it actually seemed to be coming off, altho it was a surprise."

Individuals possessed with this self-attentive attitude expressed themselves as being afraid that the experimenter was getting bored because they were slow, or that he would think them extremely stupid, etc. The principal thing, then, that occupied the minds of people with this attitude was the concern as to their general fitness and as to what others would think of them.

The suggestible attitude. Ruger says, "In two of the men there seemed to be a special sensitiveness toward any movements of the operator which might give an indication as to the course to be pursued. In such cases as this there is a lack of confidence in the self but the attention is directed not to the self but to some other person. The center of gravity, if one may so describe it, of the responsibility is located elsewhere and the suggestions, intentional or unintentional, of the other person or persons concerned are accepted uncritically. This tendency was noted by the writer in his own case in novel situations of a more distinctly social type, such as business transactions of an unaccustomed sort, or other similar cases where persons instead of things were to be dealt with and where the other person was felt to have superior information as to the matter in hand and the self to be deficient."

Probably all have experienced this attitude when attempting to do something new while in the presence of others. This is particularly true when those present are known to know more about the task than one's self. Their presence bothers us; very often we make mistakes that we know we would not make if we had been alone. Here our attention is directed even more toward those who are present than to the work before us. And at such times we are especially susceptible to any indications from these persons as to whether we are doing well or poorly.

The Problem Attitude. "In contradistinction to these two attitudes, which are certainly not favorable to efficiency," this third attitude is essentially an attitude of self-confidence. "The self-confidence is not one of sluggish complacency, however, but is expressed in a high level of intellectual activity, of attention. Attention would be directed to the thing to be done rather than to appraisal of the self."

In this particular experiment undoubtedly most subjects had somewhat of the self-attentive attitude, or the suggestible attitude, or both to start with. And as practice continued the earlier attitude faded out

more and more and the problem attitude took its place. Occasionally a subject displays only the problem attitude thruout the practice period. And occasionally also a subject continues to show the self-attentive attitude thruout, but this is rather rare. Usually there is a noticeable change toward the adoption of the problem attitude.

Some of the factors that bring about this change in attitude are the realization that one is improving, that one can do the task, that another is doing it successfully, etc. But sometimes the latter factor reacts in just the opposite way. Later on in this course, we shall return to this subject of attitude towards one's work, and endeavor to discover the causes of these attitudes and the ways in which the third attitude may be substituted for the first two. In the meantime accumulate what information you can on the subject, as it is undoubtedly one of the biggest problems a real teacher has to face—the problem of making boys and girls and men and women really self-confident about their work.

c. *Differences in feeling.* As we shall come to learn later on, *feeling* is technically either *pleasant or unpleasant.* Besides these two aspects of feeling there are the *emotions* of fear, hate, love, anger, etc. It is not likely that a real emotion is aroused in this experiment, except that of anger, and only then in the case of a few individuals.

During the first few trials the work did not go smoothly. One realized that he took altogether too much time in doing the drawing and that there were too many mistakes. Continued failure to accomplish what is desired always is accompanied by an unpleasant feeling. If this is continued too long anger will arise. But as the practice progressed, the work became easier, fewer mistakes were made, and the whole drawing took less time. With each improvement there came less and less of unpleasantness and more and more of pleasantness. So after a time the original feeling of unpleasantness changed over to pleasantness. Then one was really interested in the task.

As practice is continued, however, the improvement becomes less and less (refer again to Plates I and III. The novelty of the task disappears, and thoughts come to mind of more interesting or of more valuable performances that one might be doing if it weren't for this required task. The inability to carry out these performances because of the mirror-drawing may then bring again into consciousness unpleasant feelings. Whether one does then change from a pleasant to an unpleasant feeling-attitude toward the task at the close of the experiment will depend on the interplay of the pleasantness associated with the continued improvement versus the unpleasantness due to physical fatigue, inability to do other things, etc.

Even if one does thus swing from unpleasantness to pleasantness, and then back to unpleasantness again, one is very apt to discover that the last two or three trials bring pleasantness again to mind. Especially is this true of the last trial.

(Are these changes in feeling typical of all learning? If so, to what extent should a teacher pay attention to them as shown in his students? How might the second change from pleasantness to unpleasantness be avoided? If these changes are not typical of all learning, how do they differ here from other examples of learning?)

HOW DO CHANGES IN METHOD, ATTITUDE OR FEELING AFFECT THE CHANGES IN SPEED AND ACCURACY?

It is pretty clear that the changes in speed and accuracy produce very profound changes in method, attitude, and feeling. It is a fair question to ask, on the other hand, if the latter changes affect speed and accuracy. If they do not, it is immaterial whether the learner has a self-attentive attitude or a problem attitude, whether he is in a pleasant or unpleasant mood.

Changes in method do profoundly affect speed and accuracy. Even such slight changes as from clutching the pencil as if life depended on it to holding it naturally, result in less fatigue and consequently in smoother lines and less unpleasantness. When careful notes are kept it is often very easy to see that with a change in method there has come decided changes in speed or accuracy. In fact from a study of the time-curve and the accuracy-curve one may often be able to check up the introspections (an introspection is technically an observation of one's own mental processes) of the subject as to just when he commenced to emphasize one of these elements more and the other less.

From our analysis of the three attitudes one may have toward his work, it is clear that one is reacting in the first two cases not only to the details of the mirror-drawing itself but to other details which have nothing to do with the task in hand—details such as one's feelings, one's estimate of himself, the movements of the experimenter, etc. As one can only be affected by a certain number of details, the elimination of these useless details may make it possible for another detail in the mirror-drawing task to affect one. If this new detail is the one that must be reacted to before further progress may be made, then the change in attitude may bring about an improvement not otherwise possible. This is just what we all have noticed many times. Worry, excitement, thoughts of ourselves and others prevent the really important details for the solution of our work from coming into play. The problem attitude represents then that attitude under which we are less affected by unimportant details. The other two attitudes represent conditions

of work when certain unimportant details are being reacted to and necessarily other important attitudes are not being reacted to.

HOW ARE IMPROVEMENTS HIT UPON? WERE THEY (A) ACCIDENTAL, (B) PARTLY UNDERSTOOD, OR (C) THOROUGHLY UNDERSTOOD?

Observations from different individuals vary greatly upon this subject. One individual may proceed very slowly and observe very carefully what is to be done and just what he is doing and slowly develop the proper method for doing the experiment. In his case there will be a noticeable number of "planned out" movements. Another individual may make no "planned" movements at all, at least as far as he is able to report the matter. All that such an individual is aware of is that he kept trying first one way, then another in apparently a very aimless sort of way and that as time went on he came to realize that he was doing better and better. Moreover, from time to time he also came to realize that he was doing this particular part of the work in this particular sort of a way. For example, that when from the mirror it seemed as tho he should move his hand away from his body he then moved his hand toward his body. But the significant part of this discovery lies in the fact that he was already more or less successfully making this movement toward his body when it looked as tho he should move the hand away from him before he was conscious of the matter. That is, the improvement was hit upon apparently accidentally and later it became understood. (Later on in this course we shall come to see that the improvement was not hit upon accidentally, but was the true resultant of what had gone before, but for the present we may think of it as accidental.)

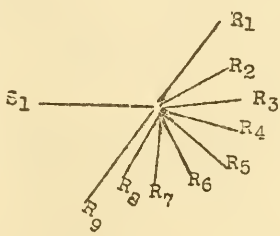
The types of learning illustrated by these two individuals appear at first hand to be very different. The first individual plans out his work, the second hits upon it "accidentally." In one sense they are very different. The former represents the highest type of human learning, whereas the latter represents the lowest type—a type common to both human beings and to animals. But when these two are carefully studied we discover that they only differ in degree, not in kind. Altho it is true that the first individual "planned" out some of his methods and movements, yet he did not plan out all of them. Many of them, usually the great majority of them, he first unconscionsly learned how to do and then later discovered that he was doing them. We shall want to characterize the learning of these two typical individuals by saying that the second unconsciously learned nearly or entirely all that he did and later became aware of part of what he was doing, whereas the first consciously planned out a few of his movements before starting to do them while learning the rest in the same way that the second individual acquired his.

Learning to do a task similar to mirror-drawing is largely characterized by the unconscious development of movements which, after they have become fairly well established, are likely to become consciously noticed. Such learning has been called "trial and error" learning. The expression is not a good one, but it has been widely used by writers on this subject. The essential characteristic of this sort of learning is that *we do not have at hand a suitable movement (response) to the situation*. In terms of situation, bond and response, there is no bond existing between the situation confronting the learner and the correct response. For example, at point 3 on the star-blank one must proceed towards 4 (situation). To do so one must make certain movements (response.) In order to do so the situation and the response must be connected by a bond. Such bonds cannot be formed voluntarily. The only way open is to try one movement after another until the right movement is hit upon. Every time an improper movement is tried it is checked immediately since it leads the pencil in a wrong direction. On the other hand, every time the correct movement is tried it is not checked but allowed to continue. In this way eventually the situation is tied up with the correct response, inasmuch as the bond connecting the two has been used more than any other. The selection of this correct movement is not consciously done. It becomes consciously known only after it is fairly well developed.

This type of learning might be illustrated roughly in this way. Suppose P and Q, who, blindfolded, are standing in the middle of a recently harrowed field or one covered with snow. P determines just to which part of the field he wants Q to go but he doesn't tell him. Q is to discover this point by keeping walking, agreeing to change his direction whenever P calls out "change" and to keep going when P says nothing. Now when Q starts he is as likely to go one way as another. The consequence is that he will start a number of times and because they are wrong P will so signal and Q will stop and start again. The snow about the starting point will become all trampled because of these starts and stops. But presently Q will hit upon the correct direction, P will no longer signal to stop and Q will continue in the desired direction. If he walks in a straight line he will presently reach the desired point. If he doesn't P will signal to change and Q will then make a few stops and starts, finally hitting on the correct direction again. In this way Q will finally reach the desired point. He has reached it thru starting many incorrect movements which were immediately checked and then continuing the correct movement whenever hit upon. Now suppose P and Q start over again. The process will be largely the same as before.

But as it will be easier walking wherever Q has traveled before, Q will be much more likely to continue in old paths than to make new ones. And as the correct direction is the only one that continues for any distance Q will be aided by it much more than by the little short paths that lead in the wrong direction. Still on the second trial Q's guidance will come essentially from P's signals. As P and Q keep up this stunt, the correct path will become better and better formed and Q will gradually come to rely on it more and more and to need P's signals less and less. After a certain number of trials it is likely that Q could traverse the distance with no mistakes, utilizing the well-worn pathway as a guide instead of the signals of P.

All learning consists in forming a new situation-bond-response combination. In forming such a new combination we must start with some already formed combinations as a starting point. In the case of drawing line 1-2 in the mirror we start with the combination of situation (direction toward one) and response (movement of hand toward body), indicated in the diagram by S1 and R1. But the response R1 is incorrect. Many other movements (R2-R8) are attempted. Each is checked immediately. Finally movement R9 (which is to move hand away from body) is commenced; it is not checked, and so is continued until 2 is reached. The old customary habit, situation (direction toward one) response (movement of hand toward body) has thus been modified so that we now have the new habit, i. e., situation (direction toward one) response (movement of hand away from body). R9 has been substituted for R1 as the response to S1. After a number of stars have been drawn this new habit will then commence to function efficiently. It will do so because the bond connecting S1 and R9 has reached a certain degree of strength.



Now the reason we "hit upon" the proper movements "accidentally" and later become conscious of them is apparently that until a bond has reached a certain degree of strength we are not capable of being aware of it. When it finally has reached this degree of strength thru use, we then suddenly realize just what we are doing. In terms of the

snow field scene Q will not at first notice that he follows his former footsteps in preference to walking thru unbroken snow. After a time, however, the difference in ease of walking along a path as compared with walking thru the snow is forced upon him. After that he is as much influenced by this detail of the situation as by P's signals. And in the mirror-drawing experiment the subject at first doesn't know how he gets from point 1 to 2. After a time, however, he realizes that to go to 2 from 1 you move in the opposite direction from what you want to, or he may not reach such a generalization but tell you that he disregards what he sees and allows his fingers to guide the movement. In the first case he has clearly in mind what he is doing. In the latter he is more in the stage of Q when he his just commenced to pay attention to the feeling of path versus no path without thinking particularly about the meaning of this difference.

Let us return now to the original question:—"How are improvements hit upon? Were they (a) accidental, (b) partly understood, or (c) thoroughly understood?" Fundamentally we have in such a type of problem as this mirror-drawing experiment a case where an old situation-bond-response combination is modified so as to give us a new response to the same situation. Whenever the response is changed there results movements more or less of the "trial and error" type, i. e., the starting of many incorrect movements which are immediately checked and the final development of the correct movement thru its being allowed to continue. In all such cases the correct movement will be "hit upon" just as "accidentally" as are any of the incorrect movements. Its first use is "accidental." Its second, third, fourth, etc., uses are also accidental. But eventually the bond connecting the situation and the new response reaches a certain degree of strength and the process becomes a conscious one. The normal thing is for improvements to be hit upon first and later to become consciously known.

But there are cases where we do consciously plan out the movement before we commence making any movements at all. These are cases which we shall study more intensively later under the heading of *transfer of training*. It is sufficient now to say that in these cases the subject has experienced somewhere else in life some situation similar to the one now confronting him and that he now makes use of some of that experience in this case. For example, a subject who has previously studied physics may have learned the principle that vertical lines are inverted as they appear in a mirror but not horizontal lines. This principle may have been connected up as a response to the situation "mirror." Now when confronted with the mirror in this experiment, the mirror detail of the whole situation in the experiment calls to mind

the physical law. The law then becomes an added detail to this subject's entire situation. He acts in terms not only of the situation as other subjects perceive it but also in terms of this detail—the physical law. And acting in terms of the law he has little or no trouble with the vertical and horizontal lines in the experiment. This statement must be modified somewhat, however. It is true he will have less trouble than the average individual if he has in mind the physical law. But he will have still considerable trouble, unless in his physics course or somewhere else he has *actually* drawn objects as seen in a mirror. When one must make a new movement in response to a situation one can only learn to make it by doing it and this doing involves "trial and error." If he has not had this experience, he will profit by knowing the law because he will much more quickly check the wrong movements since he will have a guide in not only what is *seen* but also in what is *felt* in the hands. Knowing that he must move his hands away from him in going from 1 to 2, he will feel in his hands that he is going wrong as soon as he moves in any other way.

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LESSON 13—HOW DOES ONE LEARN A SPANISH-ENGLISH VOCABULARY?

Is the learning of a vocabulary an entirely different performance from the learning of handwriting? Or are there certain parts of each that are more or less similar? What are the processes involved in memorizing a vocabulary? Is there a one "best" method for all individuals or are there different methods which are best adapted to different individuals?

In this experiment E will pronounce a Spanish word and S will be expected to give the English equivalent. If he can't E will prompt

him and a little later try him again. As the promptings continue S will gradually learn the vocabulary. Devote your time and ingenuity in this experiment to discovering how S learns the pairs of words. In some cases S will frankly not know, in other cases he will say the sound suggested the English word, in other cases he will have other answers. Endeavor to discover as accurately as possible just how S learned each pair.

A few students, particularly men, take an inordinate amount of time to learn their vocabulary. Yet if there were a thousand dollars at stake they could do the task in a few minutes. Do not allow a wrong attitude to interfere with your work. Get it done quickly.

THE EXPERIMENT

Problem: *How does one learn a Spanish-English vocabulary?*

Apparatus. E receives from the instructor a list of 25 Spanish-English words, which S is to commit to memory. (If S knows Spanish E should report this fact to the instructor and secure a vocabulary in some other language.)

Procedure. (1) E prepares a tally sheet similar to the model (Plate V) and fills in the list of Spanish and English words to be learned.

(2) E supplies S with a list of the Spanish words (but not the English words) which S will keep before him as his prompting list.

(3) Trial 1. E will read aloud to S the Spanish words and their English equivalents at the approximate rate of one pair every three seconds. S will follow with his eyes the Spanish words on his list during the reading and will endeavor to memorize the pairs as they are read. He will not write down the English words.

This first trial has, of course, 25 promptings since E read to S each Spanish word and its English equivalent. Accordingly record an "x" in column one of the tally sheet opposite each of the 25 pairs of words.

(4) Trial 2. S pronounces the first Spanish word on his list and attempts to give its English equivalent. (a) If he succeeds, then stop until you have written down S's explanation of how he came to connect the Spanish and English words together. Record these observations in detail because they are the results you are especially interested in obtaining in this experiment. When this is done S pronounces the second Spanish word and attempts to give its English equivalent. Etc.

(b) If S gives an incorrect English word, write that word in column 2 opposite the appropriate Spanish word. Prompt S as to what the correct English word is. Then have S pronounce the second Spanish word and attempt to give its English equivalent. Etc.

List the Spanish words in this column	List the English equivalents in this column	Tally below in the appropriate columns the promptings needed and errors made by S in learning the vocabulary. Trials:—										
		1	2	3	4	5	6	7	8	9	10	11
1		x										
2		x										
3		x										
4		x										
		x										
Etc.												
23		x										
24		x										
25		x										
Total number of promptings		25										

Plate V. Showing blank to be used by E for recording promptings and mistakes. (The blank should be 8½ inches wide, allowing 1½ inches for each of the forst two columns and ½ inch for the next eleven columns.)

(c) If S makes no reply within 5 seconds after pronouncing the Spanish word, mark an "x" in column 2 opposite the appropriate Spanish word and then prompt S as to the correct English word. S pronounces the second Spanish word and so continues.

Repeat the above procedure with each Spanish word in the list. In this way you ascertain whether S has learned the English equivalent for any of the Spanish words after one prompting (your first reading), and if so, how he learned it. And furthermore, you have a record of (a) How many English equivalents were given correctly; (b) How many were given incorrectly; (c) In how many cases no reply was made.

(5) Trial 3. Repeat the above procedure for trial 3. Continue with trial after trial until S can give correctly the English equivalent to each of the 25 Spanish words without error and without waiting more than 5 seconds in any case.

(6) If you still have time try this additional experiment. After S has recited the Spanish-English pairs correctly, have him start at the bottom of the list and call out the English equivalents as before, reading up the list instead of down. Continue until S can recite the list correctly. What additional light does this experiment throw on the whole problem of learning a vocabulary?

Results. (1) Count up the number of promptings (the number of "x's" plus the number of English words which were incorrectly given

in each column) and record the totals at the bottom of each column, as has been done in the model blank. Plot a prompting-curve.

(2) Record all the facts you have marshalled as to how one learns a vocabulary.

Interpretation. Answer the following questions and give any other conclusions of interest here.

(1) How does the learning curve based on promptings compare with the learning curves obtained in learning the alphabet and mirror-drawing?

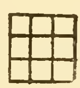
(2) In what different ways did S learn the Spanish-English pairs of words? What seem to be the general laws underlying such learning? Are these laws similar to or different from those related to learning mirror-drawing?

Application. How might these methods be cultivated? Where else could the same methods be utilized?

Hand in your write-up of this experiment at the next class-hour.

LESSON 14—THE LEARNING PROCESS INVOLVED IN COMMITTING TO MEMORY A VOCABULARY*

A foreign word may become associated with an English word in two different ways. It may be learned *thru simple repetition,* or it may be learned *thru the intermediation of one or more steps.* Take the case of the German word "hund" and its English equivalent "dog." Some individuals will come to know that "hund" means "dog" by simple repetition of the two words together. Other individuals, when confronted with "hund," will think "hound" and then "dog". When the intermediate step is employed the combination "hund-dog" may be learned with one repetition and may then function satisfactorily thruout life. When the purely repetitive method is employed the combination may only be learned after a number of repetitions and even then may not function a few days later.

Consider a second illustration. The Chinese symbol # stands for "a well of water." If one were engaged in committing a Chinese-English vocabulary, particularly at the commencement of the course in Chinese, it is most likely that the combination would be learned according to the first method indicated above—thru sheer repetition of the two together. However, if one was instructed by his teacher, that the symbol # was derived originally from  and that the four outside lines had been gradually dropped, and also that the original symbol stood pictorially for a small cluster of houses  about a common well, then it is quite likely that one would need but this simple instruction (this one repetition) in order to retain for life the combination "#—well."**

**The above explanation of the symbols is not technically correct but it is the conception that Miss Annie E. Bradshaw used in learning the symbol. The correct explanation is recorded here as given by Mr. C. W. Luh. It is of interest in this connection, as it shows how thru associations a term obtains new meanings. This word, "well," is derived from an ancient hyerograph. The square in the middle represents the mouth of the square rail of the well. Around it are walls slanting towards the ground. The resem-

*CLASS-HOUR	IN CLASS	WRITE UP	READ
14	Discuss, Lesson 13		Lesson 14
15	Experiment, Les. 15	Lesson 15	

LEARNING THRU SHEER REPETITION (Rote Memory)

Consider the fundamental process involved in learning "hund-dog' thru sheer repetition. We start with the abilities:—

(1) to pronounce "hund" when we see the printed word "hund,"

(2) to pronounce "dog" when we see the printed word "dog,"

(3) to call to mind a considerable number of words after seeing the word "dog," such as, "Toby," "animal," "four-legs," "white," "black," "yellow," "cur," etc. All of these latter combinations have been developed thru experience and go to make up as a complex whole our complex thought "dog." It is quite likely when we see the word "dog" and say "dog," that there is a more or less simultaneous commencement of the processes to say many or all of the others also.

Such abilities do not impress us as adults. But if we stop to think a moment we realize that small children can not do these seemingly simple things; hence, we must have learned them at some time.

It may be that we have never pronounced "hund" after seeing the word. But we are able to do so because of the existence of still simpler abilities which we possess, namely:—

(1) to pronounce "h" when we see the letter "h,"

(2) to pronounce "und" when we see the letters "und,"

(3) to connect up the two sounds into one word, i. e., "hund."

The more we fall back upon these simpler abilities when attempting to pronounce "hund" the first time the more slowly and with the more hesitancy will we pronounce the word, coupled with an increase in speed and confidence with successive trials. That this point may be better appreciated, watch yourself master the pronunciation of the following words: "handwörterbuch," equilibrating," "concaturating." (This type of learning is similar to learning the alphabet backwards, type 2a of Lesson 9.)

Having disposed of the problem of pronouncing "hund" when we see the printed word "hund," let us restate what we have to start with in the form of a diagram.

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blance is more remarkable when we write the word in an older style, like 

The "well system." During the Dynasty of West Chau (1122-769 B. C.) the land tax was paid in community labor. Each square (about ⅛ sq. mi.) was divided into nine allotments, like . The middle square was public land, the products of which supported the central government. Eight families were assigned to the farmsteads around it, and they worked on it as they did their own farms. The arrangement of the farms, with their fences and pathways looks just like the word #. So we have come to call it the "well system."

"For a time, it was a very effective method, and the management of these farms became a byword for order and cleanliness. So the word # became an adjective. In rhetoric we double it (# #) and this means 'very orderly.' "

	SITUATION		RESPONSE
(1)	seeing "hund"	→	pronouncing "hund"
(2)	" "dog"	→	" "dog"
(3)	" "dog"	→	thinking "Toby"
(4)	" "dog"	→	" "animal"

etc.

The problem is to connect the situation (seeing word "hund") with the existing responses to "seeing dog," i. e., to connect with the first situation in the above table the responses to the second, third, fourth, etc., situations. In terms of a diagram the problem is to develop the dotted line below:—

SITUATION		RESPONSE		SECONDARY RESPONSE
seeing "hund"	→	pronouncing "hund"		
seeing "dog"	→	pronouncing "dog"	→	thinking "Toby"
			→	thinking "animal"
			→	thinking "cur"
			→	etc.

It is apparent from our experience in the experiment of Lesson 13 that a new connection or bond, such as indicated by the dotted line above, can be developed by mere repetition. Expressed in a more general way we have:—

Situation 1	→	Response 1
Situation 2	→	Response 2

with the generalization that *repetition of $S1$—$R1$ and $S2$—$R2$ results in the formation of a new bond $S1$—$R2$.*

One of the classical experiments illustrating this law was performed by the Russian psychologist, Pavlov. He rigged up an apparatus on a dog to measure the flow of saliva. Then he showed the dog a bone and at the same time gave him an electrical shock. In diagramatic form:—

1. Electrical shock → 1. Skin withdrawn from contact.
2. Presence of bone → 2. Increased flow of saliva.

After a number of such repetitions, the bone was no longer shown and it was found that the saliva flowed in response to the electrical shock just as it had originally done in response to seeing the bone. The experiment thus demonstrated the development of the new bond.

Situation 1, electrical shock → Response 2, saliva flows

Some corollaries to the above law.

1. If one recites his vocabulary in this way:—

seeing "der"	saying "der"	saying "the"
" "hund"	" "hund"	" "dog"
" "haus"	" "haus"	" "house"

etc.,

he is strengthening not only the new bond (the dotted line in the diagram above) but also the bond of pronouncing the word when seen. If he learns his vocabulary by merely looking at the foreign word and pronouncing its English equivalent, thus:—

seeing "der"	saying "the"
" "hund"	" "dog"
" "haus"	" "house

he is strengthening mainly, if not entirely, the new and desired combination.

2. But even such a procedure does not lead to the best development of one's vocabulary. It leads simply to the connection of "hund" with "dog." If one, on the other hand, should on seeing "hund" say "dog," then "animal," "cur," "Toby," etc., he would give to the foreign word "hund" the *meaning* that attaches to its English equivalent besides connecting the two together.

Professor Gordon has demonstrated this in an experiment when one group of students studied an Italian-English vocabularly made up of the words in a stanza of a poem. They were permitted to study the vocabulary in any way they pleased for half an hour. The second group spent this half hour as follows:—(a) the poem as a whole was explained, (b) a close translation was given them, (c) the poem was read in Italian, (d) the poem was read in Italian and translated line by line, (e) the group read aloud the poem in Italian, then each member of the group did so and gave a translation, (f) the passage was read in Italian several times. Both groups were tested at the end of the half hour as to their knowledge of the vocabulary, also again a week later. The errors made by the two groups were:—

Test following study, Group I,—0.58 errors; Group II,—3.83

Test a week later, Group I,—6.30 errors; Group II,—3.50

"Thus the words learned in lists have the advantage at first but lose it later. In addition to a more permanent learning of the individual words, the second group were able to recite the poem very creditably.*

All those who have studied a foreign language have realized the force of the conclusion in this experiment. Foreign words learned as a part of a vocabulary are not learned in the same way as the same words

*Kate Gordon, Educational Psychology, 1917, pp. 173-176.

when learned during reading. The word may be known, for example, in the vocabulary but not understood in the text. There are a number of reasons for this besides the one suggested above, but let us consider it alone here. The foreign word has been connected in the vocabulary lesson with an English equivalent, but it has not necessarily been connected with the great wealth of meaning that the English word carries with it. The foreign word may call to mind the English word but the English word called to mind may not then call to mind its meaning since the foreign word is the situation to which we are primarily reacting, not the English equivalent. Under such a condition of affairs two steps are necessary before we can use the foreign word in the translation, (1) think its English equivalent, (2) think the English word's meanings. If the foreign word had been linked up originally not merely with its English equivalent, but also with that word's meanings this trouble would not have arisen. The difference between learning the meaning of foreign words in vocabularies and in actual reading comes down very largely to the psychological difference, in the first case of merely connecting the foreign word with an English equivalent, and in the second case, of connecting the foreign word with the English word's equivalent. Meaning can then be thought of as made up of the bonds that are attached to a word. The meaning of "paragraph," or "parallax," or "parallel" for any person is the sum total of ideas (bonds) that these words arouse.

All of this applies to teaching the use of new words. "Condensation," "evaporation," "expansion," "protective coloring," can be taught so that the only response is a series of words (a definition) or they can be taught so that a whole series of ideas follows requiring the writing of a paragraph to express adequately the idea. Demonstrations, experiments, discussions, etc., help here, as contrasted with the mere use of a textbook.

LEARNING THRU AN INTERMEDIATE ASSOCIATION (Associative Shifting)

Having considered at some length the process of learning a German-English pair of words thru sheer repetition, let us now consider the process when the two words are learned thru the use of an intermediate thought, e. g., "hund-hound-dog." Here again we have the same situation-response combinations to start with as before, i. e.:—

	SITUATION		RESPONSE
(1)	seeing hund	⟶	pronouncing hund
(2)	" dog	⟶	" dog
(3)	" "	⟶	thinking Toby
(4)	" "	⟶	" animal

etc.

But it is evident, in that the individual went from "hund" to "hound," that there was also the situation (seeing "hund")—response (saying "hound"). In like manner there was also the situation (saying "hound") —response (saying "dog"). There is no difficulty attaching to this second additional situation-response combination. But there is in the first case. Why did "hund" call up "hound?" They have never been together before. Can a situation call up a new response of its own accord with no previous connection between them? Yes and no. Certainly not if there has been *no* previous connection between them. "Hund" would never call up "liez," or "star" for example. But in this case, altho the total situation (seeing "hund") and the total response (saying "hound") have never been together before, there are parts of the situation which have been together with parts of the response. The letters "h-und" in "hund" have been together and in the same order in "hound." Those individuals who *saw* the connection between "hund" and "hound" did so in terms of these common details in the total situation and the response (hound). But some individuals did not see the connection at first, they discovered it after pronouncing "hund." Pronouncing "hund" became the situation which called to mind the English word "hound." And here again the details—sound of "h" and "nd" in "hund" and in "hound" have been together so that emphasis upon "h-nd" could easily lead to "hound," in fact more easily than to "hund," because "hound" is a more familiar word than "hund."

We may then explain the cause of these individuals thinking "hund-hound-dog" by stating that they reacted not only to hund as a whole situation, but to the details of that situation, and that the reaction to the details gave them a response which was already linked up with the final response they desired. This process of reacting to a situation in terms of some of its parts comes under the *Law of Partial Identity.* When we have no bond between the situation and a response (or often a very weak bond) we are quite likely to respond to the situation in terms of certain of its parts to which we already have a strong bond. In this case the bond between "hund" and "dog" did not exist or was very weak from only one or two repetitions. We consequently reacted in terms of the details "h-und" instead of "hund" and thought "hound"—the nearest response to "h-und."

There is still another factor to be considered. The Law of Partial Identity explains why the intermediate word "hound" should come to mind. But in terms of this law one would expect also to be reminded of such words as "hand" or "hind" as well as "hound." A careful analysis of what takes place in learning a vocabulary will reveal that many ir-

relevant words do flash thru the mind. But one "dismisses" them immediately, whereas one "holds on" to relevant words. Moreover, far more relevant words come to mind than irrelevant words. Altho the chances should be very decidedly against the relevant word, we shall have to explain this phenomenon on the basis that not only does the word "hund" call up "hound" and other similar words, but the word "dog" also calls up words associated with it directly or thru partial identity. As the word "hound" is brought to mind by both "hund" and "dog" and words like "hand" or "hind" or "animal" or "Toby" are brought to mind by only one of the two words, the word "hound" is far more likely to come into consciousness than any of the other words. This is an example of what is known technically as the *summation of stimuli.* A reaction is more likely to be made in response to two stimuli than to only one. One may ignore one ticklish sensation but respond violently to two.

ROTE MEMORY VERSUS ASSOCIATIVE SHIFTING

Now the essential difference between the person who learned that "hund" means "dog" by sheer repetition and the one who learned that "hund" meant "dog" thru the intermediary "hound" lies in the fact that the former developed a new bond, whereas the latter utilized bonds already in existence. And since they were already in existence one repetition of the whole was sufficient to make it function efficiently, whereas in the former case possibly several repetitions were necessary.

When a new bond is thus formed, we speak of the process as *rote memory,* whereas when already developed bonds are utilized in linking the situation with a new response, we speak of the process as *associative shifting.* The former is the simpler method and undoubtedly the more primitive, the latter is characteristic of some of the learning human beings are capable of as distinguished from what animals can do. In early life much learning is by rote memory. That is one reason we commit to memory so much material while still children. In later life, having now many bonds, we can learn thru using the old bonds rather than by developing new ones. We get the thought but not the phraseology. But even then much new material has to be learned by rote.

USE OF MNEMONIC DEVICES IN MEMORIZING

Many attempts have been made to develop artificial schemes by which one could substitute associative shifting for rote memory. And one or two such systems are constantly being advertised as panaceas for all our difficulties in memorizing names and faces and dates, etc. Here and there are persons who can utilize such mnemonic devices but with most persons it is as difficult to manipulate the scheme as to learn

the material outright. Whether one will be able to substitute associative shifting for rote memory depends on the individual himself almost entirely. In some cases he can utilize the steps employed by another, as in the case of learning the Chinese symbol for "well," but ordinarily if he does not originate the steps himself they are of little or no value.

THE EFFECT OF POSITION UPON LEARNING

The first and last two or three pairs of words were learned much more quickly than the pairs in the middle of the list of twenty-five. This is a common occurrence under such conditions. Apparently in learning a vocabulary, for example, such as:—

faire	—	do
chien	—	dog
mouche	—	fly
pied	—	foot

we not only respond with the word "do" to the situation "faire" but also to the situation "first word in the list." Likewise in the case of "chien—dog" we not only pronounce the word "dog" in response to the situation "chien" but to the situation "second word in the list" and very likely also in such a case to the situation "do," since "dog" is so similar to "do." It is apparent that these "position" situations aid us materially in committing a vocabulary to memory but later on when "faire" is met in a French story it may not be reacted to because the element "first word in a vocabulary" is missing. Learning items in terms of "position" is a risky performance if the items are to be met singly later in life.

THE PROMPTING METHOD

What we want in life is to be able to give the English equivalent of the foreign word when it is encountered (and vice versa). Thru the prompting method we are drilled in reacting to the single words just as we shall wish to do later in life. For that reason it is superior to other methods of learning vocabularies in which we are drilled to react more or less differently from the way we need to respond. The best method of memorizing a vocabulary is to prepare small slips of paper. On one side write the English term and on the other side the foreign equivalent. In studying the vocabulary pick up the slip of paper, read off the term on one side and recall its equivalent. If this can not be done, turn the paper over and repeat the two terms several times together. After thus going thru the list, shuffle the slips of paper and repeat the process. In this way the "prompting method" can be used by one person and all associations with position are eliminated.

LESSON 15—WHAT ARE THE LAWS OF RETENTION?

We have all had the experience of not being able to remember a fact or do a certain stunt which we have been able to do previously. We say we have forgotten. Let us look into this matter of forgetting and see of what it consists.

In Lesson 5 the alphabet was repeated forwards ten times and backwards ten times and in Lesson 13 a vocabulary of 25 Spanish-English words was memorized. These two experiments will now be repeated in order to discover how much has been retained and how much has been forgotten. (Obviously, if S practices before coming to class the experiment will be ruined.)

A third experiment is concerned with the extent to which we are able to retain what has been presented to us for a very short interval of time.

(Do not get excited because there are three experiments to do. They will not take very long. If necessary you can easily do the third experiment outside of class upon some friend.)

EXPERIMENT I. TO WHAT EXTENT DOES ONE RETAIN DURING A PERIOD OF TWO AND A HALF WEEKS? SHOWN IN RELEARNING THE ALPHABET.

Apparatus. Watch with second-hand.

Procedure. Have S (the same individual who was S in the Alphabet experiment in Lesson 5) repeat the alphabet (1) forwards and (2) backwards ten times each. Record the time for each trial.

Results. Plot on one sheet of co-ordinate paper (1) the curve of learning the alphabet forwards and (2) backwards as obtained in Lesson 5 and (3) the curve of relearning the alphabet forwards and (4) backwards as obtained here. (The results should be worked up after completing the next experiment.)

EXPERIMENT II. TO WHAT EXTENT DOES ONE RETAIN DURING A PERIOD OF HALF A WEEK? SHOWN IN RELEARNING A VOCABULARY.

Apparatus. The same Spanish-English vocabulary used in Lesson 13.

Procedure. Use here the same S as in Lesson 13. E prepares another blank similar to the model in Lesson 13 and writes in the 25 Spanish and English words. He supplies S with a list of the 25 Spanish words. There will be no initial reading of the vocabulary to S as was done in Lesson 13. When E and S are ready S will commence at the top of the list of Spanish words and pronounce the first Spanish word and then attempt to give the English equivalent. (1) If he does so, E says noth-

ing and S passes to the second pair immediately calling out the Spanish word and giving its English equivalent. Etc. (2) If S gives an incorrect English word, E will write that word in Column I opposite the appropriate Spanish word, and prompt S as to what the correct English word is. S next pronounces the next Spanish word, etc. (3) If S makes no reply within 5 seconds, E marks an "x" in Column I opposite the Spanish word, and prompts S as to the correct English word. Then S pronounces the next Spanish word, etc.

Repeat the above procedure trial after trial until S can give correctly the English equivalent to each of the 25 Spanish words without error and without waiting more than 5 seconds in any case.

Results. Plot (1) the curve of learning the vocabulary as obtained in Lesson 13 and (2) the curve of relearning as obtained here.

EXPERIMENT III. HOW MANY DIGITS CAN ONE REPEAT CORRECTLY IMMEDIATELY AFTER HEARING THEM. (Memory Span Test.)

Apparatus. List of digits given below.

Procedure. Using the series of digits given below, read a short series to S at the rate of one digit per second. Take the utmost care to read so as to ensure even tempo, clear articulation, and entire absence of rhythm.

While E is reading the list to S the latter should keep his mouth closed and should not repeat the digits to himself. Directly at the conclusion of the series, let S repeat as much as possible of what has just been read him. (In testing young children E should record in writing S's reproduction; with older individuals it is advisable to have S write down his own reproduction. In this case S should indicate each omission by a dash or a blank space, thus for the series, 9, 4, 7, 3, 5, 8, 6, the reply is 9, 4, 7,—, 8, 5, 6, if S is unable to remember the fourth digit and has interchanged the fifth and sixth digits.)

After having read a short series to S and having obtained his correct reproduction, read him a longer series. If he is again correct, read the next longest, and continue until he makes errors. Suppose his first error is with a series of seven digits. Then secure in all three trials with the series of six digits, three with seven digits, and three with eight digits. In other words discover the longest series that S can reproduce correctly three times, also the shortest series that S cannot reproduce correctly at all in three trials, as well as three trials with any series of intermediate length.

Credit S with his best score, i. e., if he responded correctly to all three of the 5's, to only one of the series of 6's, and no times to the series of 7's; then credit him with a memory span of 6. A correct answer means that the digits are not only all repeated but they are repeated in the original order.

MEMORY SPAN TEST

2.	7-3	1-6	8-5
3.	2-9-4	8-3-7	9-6-1
4.	5-1-8-3	9-2-7-4	7-8-2-6
5.	4-7-3-9-2	6-4-1-8-3	1-8-3-7-9
6.	8-5-1-7-2-9	2-7-9-3-8-1	9-4-1-7-3-8
7.	2-9-6-4-8-7-5	9-2-8-5-1-6-4	1-3-8-5-9-7-4
8.	4-7-2-9-3-8-1-6	7-1-8-3-6-2-9-5	4-6-1-5-8-2-9-7
9.	7-2-4-9-3-8-6-1-5	4-7-5-2-9-3-6-1-8	2-5-9-3-8-1-4-7-6
10.	8-3-9-5-1-6-2-7-0-4	4-7-0-2-5-1-9-3-8-6	2-6-1-4-0-7-3-8-5-9

In case of any mistake, additional series can be obtained by reading the above lists of digits backwards. In retesting an individual this should be done. Let each partner act as S in this experiment, if there is time.

Results. Record the memory span of each partner.

Interpretation. Answer the following questions based on the three experiments.

1. How much do you calculate S forgot during the interval of time between the first and second alphabet experiments? between the two vocabulary lessons?

2. On the basis of the first two experiments and your general knowledge, do you think that a person who had studied Latin two years would ever forget the first conjugation? Get as good evidence for your view as you can.

3. In what way is the memory-span test related to the two experiments on retention? Explain. In what ways do the two differ?

4. According to data furnished by Dr. Stiles*, children have memory-spans, as given below. In the second and fourth columns are given the average memory-spans for boys and girls and in the third and fifth columns are given the memory-spans that the poorest child of the best ¾ of each class had. The data are based on records from 751 boys and 834 girls.

	BOYS		GIRLS	
Age	Average	Division between best ¾ and poorest ¼.	Average	Division between best ¾ and poorest ¼.
6	5.3	5	5.5	5
7	5.6	5	5.6	5
8	6.3	6	6.1	5
9	6.5	6	6.6	6
10	6.8	6	6.4	6
11	6.6	6	6.9	6
12	6.9	6	6.9	6
13	6.9	6	7.2	7
14	7.2	6	7.1	6
15	7.2	7	7.2	7
16	7.4	7	7.2	7
17	7.5	7	7.7	7

* C. W. Stiles, Memory Tests of School Children, U. S. Pub. Health Service, Reprint No. 316, Dec. 24, 1915.

Dr. Gates* reports the following distribution for 163 college students in Visual and Auditory Memory Span. (His results are converted here into percentages, i. e., 0% of college students have a memory span of 4 with visually presented material, 1% have a span of 5, 9% of 6, 18% of 7, etc.)

No. of Digits	4	5	6	7	8	9	10	11	12
Visual Presentation	0	1	9	18	39	21	8	2	2
Auditory Presentation	0	7	14	18	35	18	6	1	1

In the light of the figures in these two tables and your own records what do you suppose is the relationship between proficiency in memory span and (1) age, (2) general intelligence?

5. Would you expect as good school work from a child of 12 years of age who has a memory span of 5, as you would from a child with a memory span of 7? Explain.

6. Would knowing the memory span of an individual help you at all in advising him as to the kind of job he should attempt to get? Consider such jobs as these for a girl: saleswoman in a store, cook, telephone operator, stenographer, machine operator, milliner, bookkeeper, teacher.

Write up these three experiments following the regular outline and hand in at the next class-hour. Do not forget the heading "Applications."

*A. I. Gates. The Mnemonic Span for Visual and Auditory Digits, Jour. Exper. Psychol., Oct. 1916.

LESSON 16. RETENTION (continued)*

The subject of retention has to do, of course, with the permanency of our learning. We have seen that in learning we develop a new bond between a Situation and its Response. We are here interested in discovering whether this bond remains permanently in the same condition as time goes on. When we learned the alphabet backwards we formed new bonds, for example between N and M and between U and T. After an interval of time has elapsed will these bonds function in the same way as they did just after they were formed?

Let us consider the data from a subject who did the alphabet experiment first on June 17 and repeated it again on June 23. This S repeated the alphabet twenty times instead of only ten times. His data are as follows:

Trials	Time, June 17	Time, June 23
1	26.0 Sec.	17.2 Sec.
2	22.0 Sec.	16.2 Sec.
3	22.0 Sec.	17.3 Sec.
4	18.8 Sec.	15.4 Sec.
5	17.8 Sec.	11.1 Sec.
6	19.8 Sec.	12.0 Sec.
7	19.0 Sec.	10.0 Sec.
8	18.8 Sec.	10.0 Sec.
9	26.4 Sec.	14.4 Sec.
10	28.4 Sec.	9.0 Sec.
11	16.0 Sec.	15.3 Sec.
12	16.0 Sec.	10.0 Sec.
13	16.4 Sec.	10.0 Sec.
14	12.4 Sec.	9.2 Sec.
15	11.8 Sec.	10.0 Sec.
16	14.4 Sec.	10.0 Sec.
17	9.6 Sec.	8.2 Sec.
18	14.4 Sec.	8.2 Sec.
19	11.4 Sec.	8.0 Sec.
20	11.4 Sec.	9.0 Sec.

His last trial on June 17 required 11.4 seconds and the first trial six days later took 17.2 seconds. We can say then that he has forgotten this performance to the extent of 5.8 seconds (17.2—11.4). But this does not mean that he has lost all that was gained from the twenty trials. If all had been lost it would have taken him 26 seconds on the first trial on June 23rd, as it took him that long on the first trial of June 17. Clearly, then, *one does lose during an interval of time part of what one was able to do, but one does not lose all.* Or looking at these

*CLASS-HOUR	IN CLASS	WRITE UP	READ
16	Discuss, Lesson 15		Lesson 16
17	Experiment, Les. 17	Lesson 17	

data in another way, this individual on his eleventh trial on June 17th beat his first trial on June 23rd. We might say then that he lost the effect of 10 trials during the interval of six days, i. e., the effect of the 11th to the 20th trial. But on the other hand the 10th trial on June 23rd (9.0 seconds) beat the best record on June 17 (9.6 seconds). That is, apparently only 10 trials were needed the second day to accomplish what was not accomplished in twenty trials on the first day's practice.

To sum up, then, this individual retained during the six days the effect of the first ten out of the twenty trials or an increase in rate of 8.8 seconds (26.0—17.2). He lost the effect of the last ten trials or a decrease in rate of 5.8 seconds (17.2—11.4).

As for the relationship between what one loses and what one retains, that is found to be dependent on several factors, the chief of which is obviously the amount of practice which entered into the previous learning. Without doubt the more thoroughly one learns a thing originally the better one can remember it. Hence we say that *retention is dependent upon amount of practice* or that *retention is dependent upon strength of the bond.*

THE EFFECT OF TIME INTERVAL UPON RETENTION

The results outlined above are characteristic of what one retains and what one loses during an interval of time. If the interval is very short, one of course retains proportionately a great deal of what he has learned and one loses very little. If on the other hand, the interval is very long, the relationship is reversed.

Now it is natural to suppose that the longer the interval of time the more one would forget. If one lost 10% during an interval of an hour, then one would lose 20% during a two-hour interval, or 30% during a three-hour interval. But if this proportion is carried further one would lose 100%, or all, in 10 hours and 110% in 11 hours, which is, of course, impossible. Apparently this is not the correct conception. The rate of forgetting is not proportional to the time that has elapsed. It is actually very rapid during the first few minutes and becomes less and less as time goes on. In Plate VI are given two retention curves, one worked out by Ebbinghaus[1] in 1885, and the other by the writer[2] in 1913.

In Table I are given the data on which these curves are based.

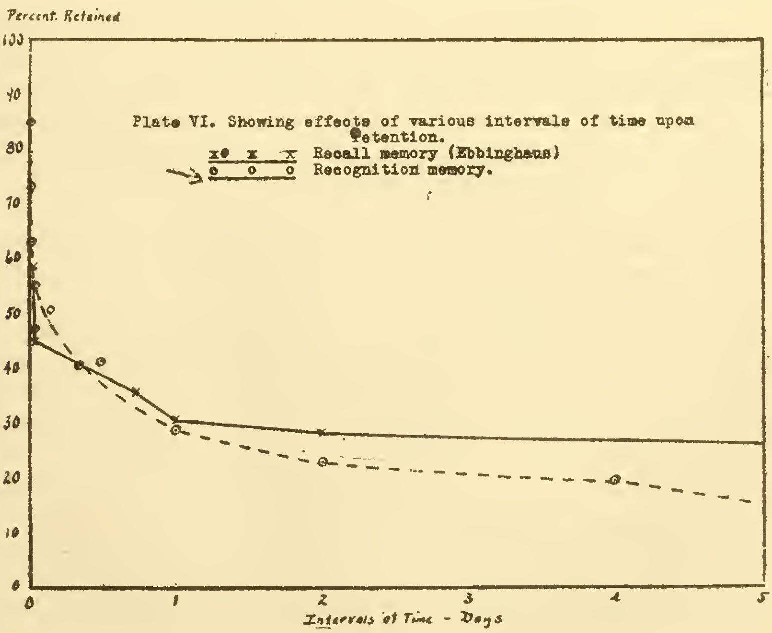
(1) H. Ebbinghaus, Ueber das Gedächtnis, Leipzig, 1885.
(2) E. K. Strong, Jr., The Effect of Time-Interval upon Recognition Memory. Psychol. Rev., Sept., 1913.

TABLE I

Per cent. Retained After Varying Intervals of Time

Interval of Time	Results of Ebbinghaus	Results of Strong
15 Seconds	——	84.6%
5 Minutes	——	72.7
15 "	——	62.7
20 "	58.2%	——
30 "	——	55.5
1 Hour	44.2	57.3
2 "	——	47.2
4 "	——	50.6
8 "	——	40.6
8.8 "	35.8	——
12 "	——	41.1
1 Day	33.7	28.8
2 Days	27.8	22.9
4 "	——	19.3
6 "	25.4	——
7 "	——	9.6
31 "	21.1	——
42 "	——	6.3

From the figures of Ebbinghaus a person retains approximately two-thirds of what he learned after 20 minutes, one-half after an hour, one-third after 9 hours, and but one-fourth after 2 days. The writer's figures show a somewhat greater amount retained after very short inter-



vals of time and a somewhat smaller amount after long intervals of time. But the principle remains the same in both. *We forget very rapidly at first and then more and more slowly.*

Retention of Motor Habits. The curves of retention given in Plate VI apply to the retention of habits that have been developed with relatively few repetitions. When we turn from such performances to others, such as dancing, skating, typewriting, handwriting, etc., we find that there is no such rapid forgetting as these curves of forgetting suggest. After one has once learned to ride a bicycle one will forget relatively little during an interval of years in which the bicycle is not touched. In such a case a person has not only learned to ride a bicycle but he has ridden it time after time until the habit has been, as we technically say, *over-learned* enormously. The extent to which we retain a habit, whether it be of reciting a poem, playing a piece on the piano, or tying our necktie depends then (1) on the interval of time since we last practiced the habit, and (2) on the extent to which we practiced the habit originally. We may draw the moral from this section that learning any habit to the extent that it will function correctly means that we know it at that time, but only much practice over and above such learning will insure our knowing it months or years later.

PHYSIOLOGICAL BASIS FOR RETENTION

The term "bond" has been used in this course to cover the nerve connections involved in learning. Later on certain phases of the nervous system will be discussed. At present only one new conception need be considered. It is that a nervous current encounters resistance in flowing over a nerve; and the more frequently such a current flows over a particular nerve the less the resistance.

A habit or memory is today conceived of as due primarily to the chemical change in the nerve connections whereby the resistance is lowered, thus permitting the nervous current to flow in this particular direction rather than in some other direction.

Consider the analogy in Lesson 12 of Q, blindfolded, learning to go in a certain direction over a snow-covered field, depending first on signals from P and later on the "feel" of the path he has previously formed as distinguished from the untrodden snow. The analogy was presented to show how a smoothly running habit could develop from mere random movements. We can liken the resistance encountered in walking thru the snow to the resistance offered to a nerve-current by a little used nerve. And we can liken the decreasing resistance encountered as the path develops in the snow to the decreasing resistance made to a nerve current by a more and more used nerve. At first it makes no difference which way Q travels thru the snow, the resistance is equal

in all directions. Later Q can travel more easily along the path he has previously formed than in any other direction. Likewise in responding to a new situation (e. g., the attempt to wag the ears) the resistance is great over every possible pathway and there results either no response at all or all sorts of random movements (e. g., frowning, winking, twisting the mouth, raising the scalp, twitching of the toes, etc.). Later the situation produces the one response (moving the ears) and no other, because the resistance over the nerves connecting situation and response is lower than any other pathway from the situation to any other response. *The new habit is dependent on the relatively low resistance of the nerves which connect situation and response as compared with the resistance of the nerves which connect the situation with any other response.* The same thing is equally true of retention (of memory). In fact, retention is synonymous with lowered resistance over nerves. The resistance is lowered by use and increases again thru disuse.

At one time memory was thought of as the storing of nerve cells, similar to storing a storage room with supplies. Such a conception is false. Memories, or habits, are nothing more or less than expressions of the fact that certain responses will now follow certain situations because of low resistance of the nerves comprising the bond.

With these facts before us we can readily see the futility of supposing that a "memory" can be recalled at any time. A "memory" in this sense doesn't exist. All that actually exists is a system of nerves with low resistance. If the former situation is encountered the proper response will follow because of this low resistance. But the response (memory or habit) will never appear unless the original situation (or a very similar situation, compare Law of Partial Identity) is presented.

RELEARNING

It is clear from what has been established that as soon as practice in learning anything ceases one commences to forget. And, moreover, that one will forget very rapidly at first and then more and more slowly. We should expect that at the commencement of every writing lesson, every music lesson, every sort of lesson, the beginner will do more poorly than he did at the end of the previous lesson. The first few minutes will be spent in *relearning* what has been lost during the interval. It is a common observation that it takes a few minutes in which to warm up to a subject. Even the athlete finds this to be the case in physical work. One should realize then that he cannot do his best work at the start, and not get discouraged but quietly and carefully go over the performance a number of times until he has relearned what he has temporarily lost. Then he can expect to be doing his best work

and to commence trying to beat his previous record—to improve his accuracy and his speed. The writer has found this to be very true in his own case in typewriting. If he endeavors to go at full speed when he begins to write he only makes mistakes and is apt to continue to make more mistakes thruout his entire period of work. But if he will content himself by going slow for a few minutes at the start he can soon go ahead at full speed making but few mistakes.

(Some writers maintain that there are two factors involved here—one due to *relearning* and another to *warming-up*. In studying the rate at which individuals work in all sorts of industries it is clear that they work more slowly early in the morning than later in the day. This phenomenon affords some evidence for a "warming up" factor related to getting started going in the day. And likewise there may be a similar tendency related to starting working at any particular task, besides that involved in "relearning." Very often we do not feel at all in the mood, as we say, and after working for some time become deeply interested and lost in the work. Possibly this change is due to other causes than relearning, i. e., bringing the bonds which are needed for our work back up to their highest state of efficiency. The writer, however, believes that the term "relearning" covers most, if not all of these cases, except in the case of the daily warming-up phenomenon.)

PRIMARY AND SECONDARY RETENTION

A mental process continues to remain in consciousness for a short interval of time. For example I look up a telephone number, lay down the book, put the receiver to my ear, and after hearing from central, say, "Hemlock 2173-L." Central in a moment replies "Line is busy." I hang up and decide to wait a few minutes and then discover the number has slipped from my mind. The retention of the number from the time it was seen in the book until it was recited to central is an example of *primary* retention. The number was really at no moment out of my mind." But as soon as it had been given to central, it was dismissed. Now if I could recall it to mind again, as I can my own house number, that would be a case of *secondary* retention or recall. The laws of forgetting so far discussed refer to secondary retention, a term which covers both recall and recognition memory. Primary memory, on the other hand, persists for but a few seconds. That it seemingly lasts longer is due to the fact that we keep repeating the contents over and over and so continue its existence in consciousness.

The most interesting fact concerning primary memory is given us in such an experiment as that of Memory Span. Here is meas-

ured the number of digits that can be retained in primary memory. An average adult can so hold seven digits. Children differ from adults in this respect. A two to three year old can retain but two digits. A little later the child can repeat three digits. And so as he grows older he acquires a greater and greater ability along this line. Defective children without normal mentality often show marked inferiority in their memory span. A child of twelve years of age with a memory span of four is most likely to be defective. Recently the writer was asked to help a young woman get a job. She was about 18 years old but had a memory span of four. Other tests showed her to be but 9 years old mentally. The failure to reach adult proficiency in memory span would shut her out of such jobs as a telephone operator or stenographer, for in both these occupations there is decided need for primary retention. In fact her low memory span emphasized the uselessness of her attempting to do any work which required attention upon a number of details at the same time. Running a simple machine or selling goods in a 5 and 10 Cent Store would be as complicated tasks as she could do. And in fact, these were the only jobs this young woman had ever been able to hold more than two weeks.

One of the most useful tests that can be made on children is this one of the memory span. When poor work in school and low memory span are found together, it is quite likely to mean that the child is dull and cannot do good work. When, on the other hand, poor work and a good memory span are found together, it is more than likely that the child is not trying sufficiently, or has become discouraged in his work for some reason or other, or has been sick and absent and missed important points in his lessons. One cannot diagnose all of a child's condition with this test, but it is an extremely good one to start with.

METHODS EMPLOYED IN STUDYING RETENTION

It might be worth while to digress a moment and consider the *methods* employed in the two investigations quoted above. Ebbinghaus made up lists of 13 nonsense syllables (such as, neb, pid, raz, tud, cor, etc.) He memorized seven such lists one after the other to the degree that he could recite the lists once correctly from memory. He then relearned the seven lists after intervals of 20 minutes, 1 hour, 8.8 hours, 1 day, 2 days, 6 days and 31 days. He kept a record of the number of repetitions that were required to learn a list originally and then relearn it. Suppose he required 10 repetitions to learn a list originally and after two days he required 7 repetitions to relearn a list. It is clear that he has saved 3 repetitions (10-7) and has lost 7 repetitions after two days as compared with his original learning.

Dividing the number of repetitions which he has saved (3) by the number of repetitions which he was originally required to make in learning the list (i. e., 10) we have 3-10, or 30%, as the amount saved or retained after an interval of two days. (This is a comparable method to that discussed on Page 68, of Lesson 14, and is techincally known as the *learning* and *saving* method.)

In the case of the writer's investigation he employed lists of twenty words. S read the list thru just once. Then after one of the thirteen intervals of time employed (e. g., 15 seconds, or 8 hours, or 7 days) S was given a list of 40 words containing the original 20 words and 20 new words all mixed in together. S was required to go thru the list and mark the words he recognized as having been in the original list. The percent recognized gave the amount retained. (This is known as the *recognition method.*)

The two investigations were based on two different types of memory. In the case of Ebbinghaus' work S had to *recall* the list. In the case of the writer's investigation S had merely to *recognize* the words he had previously seen, to distinguish between the new words and the old words. But in both cases the extent to which S could recall or recognize was due to the *strength of the bond* that had been formed during the learning. In the next chapter we shall take up the matter of the strength of the bond and consider it more fully.

SUMMARY

The principal points considered in the lesson are:

(1) Retention is dependent on (a) the strength of the bond and (b) the interval of time which has elapsed since the last practice.

(2) We forget very rapidly at first and then more and more slowly.

(3) Only thru a great amount of practice can one hope to retain a habit over a long interval of time.

(4) Relearning at the start of any practice is to be expected.

The following minor points were also touched on.

(1) The physiological basis for retention.

(2) Primary versus Secondary retention.

(3) Use of memory span test in diagnosing an individual's capacities.

(4) The "learning and saving" method of studying retention.

(5) The "recognition memory" method of studying retention.

(6) Recall versus recognition memory.

LESSON 17.—WHAT FACTORS AFFECT THE STRENGTH OF A BOND?

From our experiments on the learning process we know that practice (repetition) results in our doing the task better and better. This means that the bond or bonds connecting the situation and the response become stronger and stronger. And from our study of retention we have seen that lapse of time in which no practice occurs results in our losing some of our efficiency in the task. This means that such lapse results in a weakening of the bonds connecting the situation and response. Clearly then, use strengthens a bond and disuse weakens it.

Let us turn now and see if there are still other factors which affect the strength of a bond.

The class-hour will be devoted to a demonstration experiment. Each member of the class will consequently act in the role of subject. Carry out the instructions of E as conscientiously as possible but do not worry if you find you are not retaining all that is presented. No one can. Simply endeavor to pay attention thruout the entire experiment and to absorb as much as possible.

The total results as obtained from the class will be given to you before leaving, together with such details of the procedure as are essential for you to know. Write up the experiment in the usual manner, i. e., under the headings: The Problem, Apparatus, Procedure, etc. Work up the data as it seems best to you, bringing out the important facts and principles which are illustrated. Hand in your report at the next class-hour.

NOTE FOR INTRUCTOR. Instructions regarding giving this class experiment are given as a footnote in Lesson 18.

LESSON 18.—WHAT FACTORS AFFECT THE STRENGTH OF A BOND? (Continued)*

RESULTS OF THE EXPERIMENT IN LESSON 17**

A study of the data obtained from the experiment which was performed at the last class-hour will satisfactorily introduce the subject as to what factors affect the strength of a bond. In Table II are tabulated the results obtained from 96 men and women. Opposite each combination (as B-52 or D-84) is given the per cent. of individuals who remembered the combination, that is, the extent to which they could supply correctly the numeral when the letter was called out. In the last column an average per cent. is given for each of the different types of combinations.

* CLASS-HOUR	IN CLASS	WRITE UP	READ
18	Discuss, Lesson 17		Lesson 18
19	Review, Les. 1-18		Review, Les. 1-19
20	Examination	Lesson 20	
21	Exper. Lesson 21	Lesson 21	

** The experiment in Lesson 17 should be conducted as follows: Prepare 39 cardboard cards, 10x6 inches. The first card serves as a cover for the set. On the remainder write a letter and numeral (as G 56), occupying an area about 8x4 inches. The respective combinations for each card follow:

1	G 56	11	V 49	21	D 84	31	W 62
2	Z 37	12	E 21	22	H 73	32	X 72
3	E 2i	13	N 80	23	R 42	33	F 38
4	J 64	14	S 86	24	L 50	34	B 52
5	F 38	15	T 41	25	T 27	35	M 47
6	M 47	16	C 100	26	F 38	36	A 36
7	K 91	17	K 91	27	N 53	37	T 27
8	Q 15	18	M 47	28	E 21	38	Y 94
9	T 27	19	P 25	29	Z 37		
10	R 18	20	F 79	30	O 89		

All cards should be numbered in small figures on the back so tha tthey may readily be kept in order. On cards Nos. 8 and 31 should be pasted colored paper so that the letter-number combination appears on a colored background. (Lavender and orange-red were used by the writer.)

The instructor holds the pack of cards in one hand so that the bottom edge rests on an elevated stand. Three seconds after the signal, "Ready," he removes the cover card, exposing card No. 1. Every three seconds thereafter he removes another card until all have been exposed.

Occupy the class for three or four minutes so as to prevent them from writing down the last few combinations which they hold in mind.

Now call out the following letters and instruct the class to write down the letter and the first number that comes to mind. The letters are B, D, H, P, S, K, Z, E, M, F, T, R, N, G, Y, Q, W, C, and L. Then call out the numerals, 36, 89, 64, 49, and 72, asking for the letters associated with the numerals.

Next, repeat the lists of letters and numbers giving also the correct associations. Obtain the number in the class that got each combination correct; reduce it to percentage, and place the results on the board. Also place on the board the results in Table II.

Make plain to the class the significance of each group of data. The extent to which backward associations are formed as contrasted with forward can be pointed out from the results obtained where the numerals were called out instead of the letters.

TABLE II. SHOWING EFFECT OF REPETITION, INTENSITY AND REORGANIZATION ON ROTE LEARNING. (BASED ON RESULTS FROM 60 MEN AND 36 WOMEN.

One Repetition			
B	52	7%	
D	84	3.5	
H	73	2.5	
P	25	5.5	
S	86	6	5.%
Two Repetitions			
K	91	13.5	
Z	37	4.5	9
Three Repetitions			
E	21	35	
M	47	46.5	41
Three Repetitions of One Combination and One Repetition of a Competing Combination			
F	38 (3)	19.5	
	79 (1)	0	
T	27 (3)	19.5	
	41 (1)	2	19.5—1
One Repetition of Each of the Competing Combinations			
R	18 (1)	0	
	42 (1)	0	
N	80 (1)	1	
	53 (1)	2	0.5—1
Contrast: First Place in the List			
G	56		5
Contrast: Last Place in the List			
Y	94		3
Contrast: Colored Background			
Q	15	12	
W	62	6	9
Reorganization: Use of Old Bonds			
C	100	60.5	
L	50	20.5	40.5

Repetition. In this particular experiment when a combination was shown once it was remembered by 5% of the individuals, when shown twice it was remembered by 9%, and when shown three times, by 41% of the individuals. These figures show the value of repetition. It should not be assumed that they represent what would happen under other conditions. The more items shown the weaker is the relative value of repetition. If there were but ten addition combinations to learn a few repetitions would suffice to fixate them. But as there are many more than that very many more repetitions are necessary. The figures in the table, however, do illustrate the value of repetition. (Review here the value of repetition in learning the alphabet backwards, the mirror-drawing experiment, etc.)

Interference. In the next two parts of the experiment is illustrated the effect of interference as it works against the effect of repetition. Interference may be thought of here as equivalent to making

mistakes in memorizing the multiplication table or in spelling. When "R" is seen with "18" once and "R" with "42" once the effect is that no one remembers either combination; instead of 5% remembering both. A bond is started toward perfect development by the presentations of "R—18" connecting "R" with "18". Likewise in the case of "R—42" connecting "R" with "42." When R is presented again neither bond functions as neither has a superiority over the other. In the case where "F" was shown three times with "38" and but once with "79", 19% recalled "38" when "F" was shown again and 0% recalled "79." The competing bond (F-79) injured the other bond (F-38) to the extent of the difference between 41% and 19% or 22%.

Intensity by Contrast. In the next three parts of the table are shown three different cases of learning thru contrast. By this it is meant that the situation "G-56" is supposed to make a more intense effect than the situation "D-84" because "G-56" was the *first* combination which was shown, whereas "D-84" was shown somewhere in the middle of the list. "Y-94," the *last* combination to be shown, is also supposed to make a more intense effect than the average simply because it comes last. In this particular experiment the first and last combinations are no better remembered than any of the others. In some experiments they are remembered to a greater extent. The writer is convinced on the basis of experiments, including from 10 to 150 items, that the first and last place are important in a short series but unimportant in longer ones.

Intensity may be illustrated in other ways than in terms of the first and last place. In the case of "Q-15" and "W-62" we find they were better remembered than the average because of their *colored background.* On the basis of more extensive experiments the writer is convinced that such a type of intensity is not so effective as indicated here by the data. Possibly, the true situation is this. If only one or two items are made prominent by a colored background then they are noticed to a considerable extent and so remembered. If many items are made prominent, the intensity factor becomes much less valuable. Contrast the value, for example, of one colored advertisement in the Saturday Evening Post as against twenty or one hundred.

Prominence (intensity or contrast) may aid in learning because the item is singled out and noticed more than the others and, therefore, remembered better.

Reorganization. The reorganization factor is intimately tied up with the bond to be developed. This means that "C-100" or "L-50" have already been partly learned and that previous learning is now made use of here. Just as in the case of "hund" and "dog" calling up

"hound" and thereby linking "hund" with "dog" by way of the intermediate step of "hound," so in this case "C" and "100" call up the Roman system of notation where "C" stands for "100" and as soon as that is done the "C" in this particular experiment is thought of as linked with "100." About 55 out of the 96 men and women connected "C" and"100" together and so remembered the combination. In their case the new detail (Roman system of notation), as soon as it was recalled, became a part of the situation, so that when later the instructor called out "C," they reacted not only to "C" but also to the new detail and consequently wrote down "100."

WHAT FACTORS AFFECT THE STRENGTH OF A BOND?

In order to make sure that these various factors are clearly understood let us go over the subject again. We have just mentioned four factors as affecting the strength of a bond. Lessons 15 and 16 emphasized the negative side of this matter, i. e., that disuse weakens a bond. Accordingly a fifth factor may be added to our list, i. e., that of "recency." A sixth factor, "effect," will be considered for the first time. The six factors are:—

1. Repetition.
2. Interference.
3. Intensity: (a) intense stimulation, (b) primacy, (c) contrast.
4. Reorganization: (a) use of old bonds, (b) novelty—new combination of old bonds.
5. Recency.
6. Effect.

Repetition. We clearly realize that a bond is strengthened thru repetition. Our learning in the alphabet, mirror-drawing, and vocabularly experiments clearly showed this fact.

Interference is a factor in affecting the strength of a bond. We have here the formation of two bonds connecting the same situation with two different responses. As both responses can not be made at the same time, when the situation is presented, no response results. If a child in reciting the multiplication table says 9×7 is 63 and later says 9×7 is 67, when called on by the teacher for the answer to 9×7 he will make no reply in most cases, or wildly guess. To strengthen a bond requires then that no competing bonds be formed at the same time. After a bond has been well developed, however, a new bond may be developed without any great injury to the old one. Herein lies one of the reasons for teaching the addition combinations first and then the multiplication combinations afterwards. If they were taught at the same time there would be great confusion. After the first have been well learned then the latter can be readily learned. But even here

it is an advantage to keep them apart in the school work until both are fairly well developed.

Distraction is another phase of interference. The playing of a piano in the next room intereferes with my studying. Here there is competition between situations, i. e., "music" and "algebra" rather than between the responses to the same situation.

Intensity: (a) intense stimulation. Of two repetitions the one that is the result of the greater stimulation will result in the greater development of the bond. A tiny burn on the skin will not make us leave the hot radiator alone like a large burn. A fact learned under quiet conditions will not be remembered so well as one which is intimately connected with strong emotional excitement. In physiological terms the release of a large amount of nervous current by stimulation of the sense organs will more materially affect the nerve connections than will the release of a small amount of current. This is the basis for the factor of intensity as it affects the strength of a bond. In our experiment there was no adequate example of a violent stimulation. If there had been that combination would have been exceedingly well remembered. This might have been accomplished in the experiment by having exposed a combination twice or three times as long, or by having the instructor call out the combination as he showed it. But neither of these are comparable to the intense stimulation we experienced when we caught a bee the first time. Thruout life that one experience of being stung is remembered and we markedly differentiate bees and other insects. The artificial production of great stimulation is extremely difficult to accomplish in influencing others. The orator tries to bring it about by arousing our emotions and driving home his point thru this added excitement. It is done sometimes thru punishment. But after all it is difficult to do and seldom done in a very effective manner. What is actually done is to employ, what has been called here, *contrast* effects.

Intensity: (b) primacy. Primacy in the sense of the "first response to a situation" derives its strength from lack of interference. When once a child has pronounced a word incorrectly or has named an object incorrectly it is a very much more difficult task to correct the error than to teach a new word. Often primacy is confused with intensity, as in the case of catching a bee. In the experiment, "G-56" can hardly be construed as an example of primacy as this is not the first time a response has been made to "G."

Intensity: (c) contrast. The contrast factor has reference essentially to a difference which is not a vital part of the bond to be developed. For example, "G-56" occupying first place in the list is remem-

bered better than "D-84", occupying an inconspicuous place in the list. Position is not intimately tied up with the bond connecting G with 56 or D with 84. The same is the case with the combinations "Q-15" and "W-62," which had colored backgrounds. The contrast factor of difference in background is not intimately a part of the bond to be developed connecting Q with 15 or W with 62. These contrast effects do tend to single out the particular combinations so favored and because they are singled out they are more intensely noticed and so retained. But this additional gain amounts to only a few per cent. in most cases.

The fact that different degrees of stimulation do affect the strength of the bond must not be overlooked. But, as already pointed out, this is difficult to accomplish. What generally is resorted to is contrast. And this is often of no particular value. Sometimes, it is worth while, but it does not compare in value with the factor of reorganization.

Reorganization: (a) use of old bonds. Reorganization is also a factor in strengthening a bond. It is not a factor in the development of a really new bond, of course, but from the practical point of view of learning it is a most important factor since a great deal of our learning consists of linking a situation with a response by means of already established bonds. To link "hund" with "dog" by means of the element "hound" is just as truly learning as to connect them directly together.

Two degrees of reorganization may be recognized, (a) thru the use of old bonds, or (b) thru the use of old bonds combined in a new way (novelty). Both are most effective but the latter is the better of the two.

The case of learning "C-100" thru linking up "C" with "Roman notation" is an excellent example of the use of old bonds. So also is that of learning that "hund" means "dog" thru utilizing "hund-hound" and "hound-dog." The old, old adage in education of "going from the known to the unknown" in teaching covers this point because when we start in to teach a new thing and first consider all of its phases which are already known, the child connects it up with old bonds and so utilizes them in learning.

Reorganization: (b) novelty—new combination of old bonds. In this type of reorganization we use old bonds as in the cases just discussed, but we go farther and present them in a new or novel combination. The writer was lecturing one hot day just after lunch, upon this subject and the students gradually became more and more listless and inattentive. Now either contrast or reorganization could be utilized to get their attention. The writer could have talked louder, or paced up and down the room, or written on the board, etc. All these

would be contrast effects and would have some effect. Instead he described in his ordinary tone of voice an advertisement entitled something like this, "How does——— (an actor) make a cat yawn on the stage every night?" Immediately, the class was awake and paying attention. Why? Because a situation made up of details with very old and well developed bonds was presented. And the combination was new. The words "cat," "yawn," "stage," and "night," have very strong bonds. Such a novel reorganization of old, familiar situations will always attract attention (i. e., be responded to) and will easily be retained.

There is a profound difference between learning *a new thing* and learning *a new combination* of old things. The former is most uninteresting and difficult to "get a hold of," despite the popular notion. Consider how uninteresting the first lesson in physics or algebra was, or how little you read of foreign countries you have not visited. On the other hand, consider with what interest the expert milliner reads over technical discussions of the latest styles, or a botanist seizes upon a new flower, or you read descriptions of places you have visited. The average visitor to Niagara Falls or Yosemite is very often disappointed at first. The scene is too new to make an impression. But as he continues to drink in the scene for several days it grows and grows on him because he has commenced to link it up with his other experiences. A big dog is a contrast to an ordinary sized dog. It arouses some notice and is more likely to be remembered than the average dog. But a dog with a pipe in his mouth is a novelty—a new combination of two old familiar things (dog and pipe). That dog draws a crowd.

In teaching, in advertising,[1] or in any field where one desires to create an impression and have it retained, that impression can be most easily and efficiently accomplished by linking up the parts of the new impression thru the use of old bonds, old ways of thinking. A novel presentation (i. e., one capable of reorganization by the learner) accomplishes most. And it is efficient just in the degree that the old is utilized by the learner in connecting the new together. Contrast effects, such as increasing the size of the type in an advertisement or the size of the advertisement itself, or giving it a colored background, or yelling at the class, or writing an assignment in pink chalk, or wearing a florid necktie, do not aid particularly in developing the new bonds presented in advertising, teaching, or salesmanship, and some-

(1) See H. L. Hollingworth, Advertising and Selling, 1913, Chapters V and VI for an extended discussion of the factors of contrast and novelty as utilized in advertising.

times they positively interfere thru distraction (interference).

When the lesson can only be learned thru the development of *new* (actually new) bonds, then drill (repetition) is the only solution. This does not mean that the lesson need be recited over and over in the same way. No. Proper drill is repetition carried on in various ways so that the learner will not tire of the monotony, but will be stimulated by changes in the performance; and where nevertheless the essential part is repeated again and again until mastered.

Recency. The experiments in relearning the alphabet and vocabulary have clearly demonstrated that we forget, that our bonds do deteriorate if they are not used. The more recently we have performed an act the better can we do it again.

Effect. In addition to the foregoing five factors which affect the strength of a bond. Thorndike lists a sixth—that of effect.[1] When we make a response to a situation and feel satisfied or pleased, then the bond is strengthened because of the satisfyingness. When the response is followed by dissatisfaction, the bond is weakened because of the dissatisfyingness. Moreover, the closer or more intimate the relationship between the performance and the satisfaction or dissatisfaction the more pronounced is the effect upon the strengthening or weakening of the bond.

Psychologists are not all agreed upon this point. Some, like Watson[2], deny the existence of such a factor. Others, like the writer, are not agreed that Thorndike's explanation is correct but accept the practical results as stated by him. This is not the place to consider the technicalities of the controversy. From our standpoint, the practical implications are true.

Effect influences learning because the resulting satisfaction or dissatisfaction establishes, first, a standard in terms of which successful movements are repeated and unsuccessful ones discontinued, and second, the organism continues a process which gives him pleasure and discontinues a process which gives him displeasure. All of Watson's experiments in which he rewards the correct movement and punishes the incorrect ones bear this out. His rats choose the former because they are so constituted that they go toward food and not away from it, avoid an electric shock instead of seeking it. We develop habits which result in our being able to do what we enjoy and we do not form habits which result in unpleasantness.

The Law of Effect which we add to our five other factors means, then, that learning is dependent (1) on the presence of some standard

(1) E. L. Thorndike, Educational Psychology, 1913, Vol. II., p. 4.
(2) J. B. Watson, Behavior, 1914, Chapter VII.

which determines when the learning process (random movements) is ended, (and it is ended when we obtain a more satisfactory state than before, or are completely exhausted) and (2) on the fact that we will continue pleasant responses but will not continue unpleasant ones.

The second thought in Thorndike's statement is also important. The sooner after the movement has been made that we know we are on the right track or on the wrong track (i. e., experience pleasantness or unpleasantness), the greater is the value of this factor in learning. If a child has spelled incorrectly or disobeyed his mother then immediate punishment is far more efficient than delayed punishment. In fact, in teaching animals or small children only *immediate* praise or punishment is worthy of consideration. As one grows older one can profit from satisfaction or dissatisfaction after much longer intervals between the execution of the act and the resulting realization that one has performed the act correctly or incorrectly. Nevertheless the shorter the interval of time the greater the value of this factor of "effect." Conscientious high school or college teachers of English labor for hours making detailed corrections in grammar, etc., in themes and then wonder why the same mistakes are made again and again. One reason is undoubtedly that the correction follows so long after the act. Immediate correction would accomplish wonders here as contrasted with this long delayed arousal of dissatisfaction. Grammar school teachers, on the other hand, require each child to write his lesson on the board and call upon him to defend it before the class. Here the interval between execution and realization is reduced to a minimum.

MISCELLANEOUS FACTORS AFFECTING LEARNING IN GENERAL.

Individuals differ in ability to learn, as we shall see in lessons to follow. Some are bright and quick, others are dull and very slow. The age of the individual is a factor. Experiments prove that we improve in learning capacity as we advance from childhood to maturity. General health also affects learning, altho not so much as is popularly supposed. A hard cold interferes because it makes us loath to work. Probably, if we tried as hard, we would learn just about as well.

The next class-hour (the 19th) will be devoted to a review of Lessons 1-18, followed by a written examination during the 20th class-hour. Read over Lesson 19 in connection with the review.

LESSON 19—THE LEARNING PROCESS IN GENERAL

SOME BONDS ARE UNLEARNED, OTHERS ARE LEARNED.

All acts of behavior involve a response to a situation. And this condition postulates the existence of a bond between situation and response. It is evident from the experiments which have been performed that bonds are formed—that at one time in a person's life certain bonds did not exist which later came into existence. Such changes are what is meant by learning—the development of new bonds. A still closer study of man's behavior, especially when he is an infant, leads us to realize that there are some bonds which do not develop thru the process of learning. Such bonds develop naturally: just as naturally as do man's teeth, hair, blood vessels, or digestive system. Situation-bond-response combinations which develop naturally are referred to as *reflexes* or *instincts*. Combinations, on the other hand, which are developed thru learning are termed *habits*.

Reflexes and Instincts. A reflex is an act in which there is a single situation as the cause of the stimulation followed by a simple response, the bond or connection between sense-organ and muscle being unlearned. Reflex acts are such as, jerking the hand away from a hot stove, winking when an object suddenly comes toward us, coughing when the throat is irritated, etc. An instinctive act, on the other hand, is one in which there is a more complex situation, ordinarily, followed by a more complex response, the bond being also unlearned. Instincts would be illustrated by such behavior as a mother's interest in her baby, fear and flight from a large animal, a boy's interest in girls, etc.

There can be no sharp line of demarcation drawn between reflexes and instincts any more than all men can be divided into two groups of short and tall men. Some men are undoubtedly short or tall, just as some of these unlearned acts are clearly reflexes or instincts. But most men are neither decidedly short nor tall. In the same way most unlearned acts can be classified either as reflexes or instincts depending upon the definitions set up. In a general way, reflexes are simple acts, involving little or no consciousness of what is being done and seemingly an action carried on by only a part of oneself, as my hand, my eye, etc. Instincts are more complex, consciousness is involved, and I feel that I myself am involved, as when I pet a baby, or run from a bull, or get interested in a girl.

The most important point to note in all these cases is that the response is always one that is made naturally without any training. In other words, the *bond* connecting situation and response is ***unlearned.***

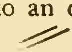
It is not a part of this treatise to consider the subject of man's in-

stincts. The subject is large enough and important enough to warrant an equal amount of space to it as is given here to the learning process. But it should be realized that man is equipped by nature, thru his reflexes and instincts, to respond in certain definite ways to thousands of situations which will confront him in life. This means that nervous connections are already formed between sense-organs and muscles, so that when man is confronted with certain situations he responds automatically, immediately and without conscious guidance.

Habits. On the other hand, habits are situation-bond-response combinations which have been developed thru training. At one time there was no bond Unless such new bonds were formed man would not advance beyond the limits of his reflexive and instinctive equipment.

HOW ARE NEW BONDS FORMED? THE LEARNING PROCESS

Associative Shifting. A habit may develop from a combination of two already formed situation-bond-response combinations. This process we have called associative shifting. (See Lesson 14.)

Trial and Error. The second method of learning involves those cases in which we are confronted with a situation to which we do not have the correct response. Either the movement or movements which are required for the appropriate response have never been made at all or the particular grouping of movements has never been made. So we learn thru *random movements.* For example, I may learn to wag my ears altho at the present time I cannot move them. Or I may learn to trace a diagonal line in the mirror after practice. In this case I must make not a new movement itself but a new combination of two movements in response to an old situation. Suppose the line appears like this in the mirror  Ordinarily I would trace between these lines by moving my hand to the right and away from my body. But in the experiment I must move my arm to the right and toward the body. This new combination must be learned thru "trial and error," particularly when I am not aware of just what the situation is. Even if I did know the above facts, altho that would aid me decidedly, still I should have to learn to make the new combinations thru "trial and error."

As a seven-weeks' baby lies in its basket it will be observed to kick its legs, turn in a twisting manner, draw up its arms, cry, wrinkle its face, kick again, turn its head, etc., and possibly once in an hour of such struggling emit a single vowel sound. All of these movements are parts of its repertoire of movements, all belong to this or that reflex or instinctive movement soon to ripen into the complete smooth working reflex or instinct. The single vowel sound is a part of the reflex action of crying but in a sense it is not a part of that reflex when occur-

ring all alone. Occurring all alone it is an accidental happening: part of the crying reflex was stimulated but not all. In early life, particularly, the nervous system generates an excess of energy which activates, because of the excess, not only the appropriate muscles connected with the stimulations of the moment but also other muscles which do not, of course, produce movements in perfect keeping with the stimulation. Thus because of this *overflow of energy* from time to time other movements than reflex and instinctive movements take place. In this way the vowel sound appears. Once having occurred alone, separate from crying in general, according to the laws of practice, it is likely to occur again. And so as we watch the baby develop we find the single vowel sound occurring more and more often until finally it becomes a regular part of its total repertoire. (Review here again Lesson 17 as it refers to this point.)

If a situation to be properly reacted to requires a new movement, the learning must take the form of "trial and error."

PERCEPTION ANOTHER TERM FOR HABIT.

A perception is a type of learned performance where the emphasis is not upon the muscular response but upon the content we have in consciousness. For example, I meet a baby on the street. When I smile, enjoy the cunning baby, etc., the response is mainly *instinctive*. When I call out, "Hello, what are you doing?" the response is mainly *habitual* (I learned to talk and to salute babies that way). When, on the other hand, I mainly contemplate the baby and am conscious of its pretty hair, bright eyes, pink dress, dirty face and hands, etc., the response is termed perceptual—the emphasis is not upon what I do (whether instinctive or habitual) but upon what is in my consciousness. The term perception is used so extensively in psychology and education that it is important to understand its use.

Consider this case of the development of a percept. It is learned both thru associative shifting and random movements. A rattle is placed before a baby.

SITUATION	RESPONSE
Rattle near by (retina of eye stimulated)	eyes focused on object (i. e., reflex movements of muscles controlling lens, convergence of two eyes, movements of head, and possibly much of the upper body) (Visual sensation in consciousness) reaches for rattle (leading to what follows.

Fingers touching rattle (skin stimulated)	fingers close about rattle (touch sensations in consciousness), followed by further cutaneous[1] and kinæsthetic[2] stimulations being aroused which in turn bring about new manipulatory movements.
	manipulatory movements, which cause new visual stimulations, also auditory stimulations.
Noise of rattle (ear stimulated)	head turned so as better to hear noise (i. e., reflex movements of muscles which turn head and possibly upper part of the body) (auditory sensations in consciousness).

After a short time it is clear that any one of the stimulations thru touch, vision, or hearing would immediately call up any one or all of the responses listed above. In this way thru continued experience what we call the *perception* of a rattle becomes established. In other words, seeing or touching or hearing a rattle becomes associated with how it appears, feels or sounds so that the sound alone, for example, arouses in consciousness a percept of how it appears, feels to the touch, and sounds.

It is customary to call these learned reactions in the case of the rattle *perceptions*. They are *habits* just as much as in the case of saying "dog" in response to "hund." From continued repetition of certain situations, together with their responses the various situations become connected up with the responses of the other situations, as well as with their own responses. Apparently this process of thus connecting up new responses with situations is one of the most important functions of the nervous system.

SUMMARY.

In reviewing what we have learned concerning the learning process, it is clear that we started with certain situations which are connected up with certain responses thru heredity or previous experience, and we have formed new connections by having the parts presented one or more times together. These new combinations of situation and re-

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(1) Cutaneous stimulations are stimulations affecting the skin, giving one, in terms of consciousness, touch, pain, warmth and cold and combinations of these. (Lesson 35 will present the subject in more detail.)

(2) Kinaesthetic stimulations are stimulations affecting sense-organs, located in and about the muscles and joints, giving one, in terms of consciousness, movement, weight, pressure, etc. (Discussed further in the following lessons.)

sponse are *habits;* they are *learned* connections in contradistinction to *reflexes,* which are *unlearned* connections.

Also because of our psysical nature, which is so constituted that changes can take place in it, new situation-bond-response combinations can be formed (i. e., habits). These habits appear thru the combining or modifications of reflexes, instincts, and already existing habits. The overflow of nervous energy resulting in random movement is an important factor in the development of these habits.

WHAT THE LEARNING PROCESS MEANS TO EDUCATION

Evidently, *learning is connecting.* It is the forming of a bond between a situation and a response; the development of a habit. Clearly also, early in life the new connections will be slight modifications of reflex and instinctive actions; later the new connections may join great groups of complex habits together into such complicated processes as playing the piano or solving an original in geometry.

Teaching is, then, *the manipulation of the details making up the situations which confront children so that as they respond they will constantly form new habits and, moreover, habits that are desirable ones.* If the desired responses are new ones for the child then the learning must be of the "trial and error" type. But if the desired response is one that is already a response to another situation the new situation and old response can be connected together thru associative shifting. For example, take the case of a boy learning to climb over a wooden fence. If he goes at it alone it will be largely a matter of "trial and error," because he will not analyze the entire performance into parts each of which he is already capable of doing. But if one who understands the movements to be made stands by and calls out, "Now climb the ladder" he will make the movements previously associated with climbing a ladder. "Now put one leg over the top," he will respond by throwing one leg over the top board, as he has often done in climbing out of his crib. "Now cross your hands," "Now put the other leg over," "Now face me," "Now climb down," he will climb over the fence in a fairly smooth and efficient way the first time. He does so because he has utilized old responses, one at a time, and he has utilized them because the old situations connected with them have been presented by the parent in the proper sequence. A little practice, then results in connecting all of these responses together in a string just as the responses in saying each letter of the alphabet are connected to-together.

In what has gone before we have obtained a general conception of the learning process and of the mechanism by which situations become linked up with responses. In the lessons to follow we shall take up the matter of learning in greater detail. But the whole subject centers about

this main theme just expressed that the child's learning is conditioned by the skill the teacher displays in presenting situations to him. Lessons are difficult or easy depending not on the material of the lesson, ordinarily, but upon the order of presentation of the details in the lesson—an order depending upon what habits the child has already acquired.

The next class-hour (the 20th) will be devoted to an examination covering the work of the course.

LESSON 20—MEASURING DIFFERENCES OF PERFORMANCE AMONG INDIVIDUALS

The general characteristics of learning have now been presented. Differences between individuals have so far been ignored in our eagerness to discover the common principles found true of all individuals.

It is important to stop now and resurvey some of our material to see to what extent individuals are alike and to what extent they are different, and in what the differences consist.

In order to make these studies effectively it is necessary to become familiar with three mathematical conceptions, known as the "average deviation" (discussed in this lesson), the "normal curve of distribution" (Lesson 25), and the "coefficient of correlation" (Lesson 31).

All of these conceptions are basic to modern psychology, as well as to biology, sociology, economics, education, etc., and are worth understanding for their own sake, as well as for their use as tools in applying scientific principles to everyday problems.

THE AVERAGE DEVIATION.

Two fourth grade classes (A and B) were given the same test. The scores of the twenty students were as follows:

CLASS A		CLASS B	
Pupils	Grades	Pupils	Grades
1	96	21	87
2	88	22	80
3	80	23	74
4	80	24	73
5	68	25	64
6	68	26	63
7	60	27	58
8	60	28	57
9	56	29	56
10	56	30	55
11	52	31	53
12	52	32	52
13	44	33	46
14	40	34	43
15	36	35	41
16	36	36	40
17	24	37	32
18	24	38	31
19	24	39	30
20	16	40	25
Total	1060		1060
Average	53		53

When we average the twenty grades in each class we find the averages are the same, i. e., 53. But when we look over the scores we discover immediately that the two classes are not equal in performance.

Class A has two students superior to any in Class B and four students inferior to the poorest in Class B. As far as this particular test is concerned it shows that the students in Class A are more unlike among themselves than are the students in Class B. In other words, there are greater differences in ability in Class A than Class B.

Such differences in ability in classes form an important consideration in the administration of a school. For the more homogeneous a class, the easier it is to handle. One of the duties of a principal is to assign pupils so as to have the smallest differences possible in a class. We shall come to appreciate this point more fully in the next few lessons.

It is clear that to state that Classes A and B have the same average is not sufficient. The total grades tell us another important point. But it is extremely awkward to have to reproduce in a report all of the grades of the pupils. Is there not some short-cut method by which these individual differences can be expressed?

It is just this, that the "average deviation" does give us. It is a measurement used as a supplement to the average in studying individual differences. This measurement means exactly what the two words imply—the average amount of difference of the individuals making up the group from the average of the group as a whole. Consider carefully how it is obtained in the following examples (Table III). First, the average of the figures themselves is obtained. Second, the difference between the average and each separate figure is obtained. Third, the average of these differences or deviations is obtained. This is the average deviation (A. D.)

Knowing the average for each class and the average deviations, i. e.,

Class A Average 53, A. D. 18.2
Class B Average 53, A. D. 13.7

we can readily determine, if we do not have the original data, that there was a very great variation in the individuals. But of the two classes Class B is more homogeneous. We know now for certain that the average does not represent what all twenty pupils did. Far from it. Some must have varied above and below 53 by more than 18.2 (or in Class B more than 13.7) in order that the average of all the deviations should be 18.2.

It is mathematically true that very few cases will ever differ from the average by more than three times the A. D. For example, it is unlikely we would have pupils in Class A with grades higher than $53+(3\times18.2)$ or 107.6, or lower than $53-(3\times18.2)$ or -1.6; and in Class B higher than $53+(3\times13.7)$ or 94.1, or lower than $53-(3\times13.7)$, or 11.9. In these particular classes we do not have any cases varying as much as these limits.

TABLE III. ILLUSTRATING THE METHOD OF OBTAINING THE AVERAGE DEVIATIONS (A. D.)

The left hand of the table illustrates the work involved in obtaining the A. D. of the grades of the 20 pupils in Class A, while the right half of the table shows similarly the work involved in obtaining the A. D. of the grades in Class B.

CLASS A			CLASS B		
Pupils	Scores	Differences	Pupils	Scores	Differences
1	96	96—53=43	21	87	87—53=34
2	88	88—53=35	22	80	80—53=27
3	80	80—53=27	23	74	74—53=21
4	80	80—53=27	24	73	73—53=20
5	68	68—53=15	25	64	64—53=11
6	68	68—53=15	26	63	63—53=10
7	60	60—53= 7	27	58	58—53= 5
8	60	60—53= 7	28	57	57—53= 4
9	56	56—53= 3	29	56	56—53= 3
10	56	56—53= 3	30	55	55—53= 2
11	52	53—52= 1	31	53	53—53= 0
12	52	53—52= 1	32	52	53—52= 1
13	44	53—44= 9	33	46	53—46= 7
14	40	53—40=13	34	43	53—43=10
15	36	53—36=17	35	41	53—41=12
16	36	53—36=17	36	40	53—40=13
17	24	53—24=29	37	32	53—32=21
18	24	53—24=29	38	31	53—31=22
19	24	53—24=29	39	30	53—30=23
20	16	53—16=37	40	25	53—25=28
Total	1060	364		1060	274
Av.	53	18.2		53	13.7

The A. D. is 18.2—the average of the differences (deviations).

The A. D. is 13.7—the average of the differences (deviations).

PROBLEMS

Find the A. D. of the grades in the following classes:

1. Class C is composed of pupils 1, 3, 5, 7, 9, 11, 13, 15, 17, and 19 in Class A given above.
2. Class D is composed of pupils 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20.
3. Class E is composed of pupils 1 to 5, and 16 to 20.
4. Class F is composed of pupils 6 to 15, inclusive.

Check your answers with the instructor at the next class-hour. If incorrect spend part of that hour making sure you understand how to get an A. D.

NOTE—Bring co-ordinate paper with you to the next class-hour.

LESSON 21—HOW DO INDIVIDUALS DIFFER IN LEARNING MIRROR-DRAWING?

We have so far studied a number of learning curves. We have discovered some general facts about the process of learning,—about the process of learning taken on the average. But it is worth while to stop and consider whether all individuals learn in the same way.

We know that people differ. We know that they differ in the way they do a certain lesson, that they differ in the time it takes them to learn the lesson, in the way they answer questions about the lesson, etc. We know some get good marks and some get poor marks. Why are there all these differences? What are the causes of individual differences?

Let us consider just one of these problems. Let us study the data from 10 individuals in the mirror-drawing experiment and see in what respects they are alike and in what respects they are different.

Below are given the results of ten individuals (called A to J) in the mirror-drawing experiment. The records are a combination of their time and error data. Endeavor to discover by yourself, together with the help of your partner, as many ways as you can in which these records are (1) alike and (2) different. That is, exactly what are the characteristics which are common to the learning of these ten individuals and on the other hand, in what respects do the records of their learning differ?

TABLE IV. RECORDS OF TEN DIFFERENT INDIVIDUALS (A—J) IN MIRROR-DRAWING EXPERIMENT*

Each figure represents the time consumed in doing the drawing plus the number of errors that were made in that drawing.

Trials	A	B	C	D	E	F	G	H	I	J	Average
1	232	76	210	363	216	286	283	701	129	131	263
2	193	77	152	167	147	144	148	184	94	90	140
3	157	80	115	128	160	109	69	148	98	75	114
4	115	68	108	143	113	141	66	144	91	67	106
5	133	70	108	132	110	97	76	98	84	75	98
6	88	57	115	125	103	99	59	90	69	64	87
7	87	65	96	121	90	97	50	87	67	67	83
8	90	62	92	149	91	111	53	81	75	51	86
9	102	65	62	140	92	101	48	79	70	49	81
10	88	54	71	121	75	89	56	72	55	49	73
11	102	59	68	121	90	115	56	71	66	51	80
12	88	63	59	112	74	87	51	58	57	55	70
13	87	51	56	95	64	90	50	63	55	47	66
14	79	57	58	95	70	87	44	56	59	46	65
15	89	53	60	86	75	81	43	55	59	38	64
16	64	48	55	114	59	84	38	54	51	44	61
17	68	46	61	100	62	81	36	54	59	43	61
18	71	37	53	116	59	71	43	62	54	30	60
19	55	49	42	122	51	69	40	53	52	31	56
20	61	50	58	85	52	70	35	60	40	36	55

The Use of Tables of Statistics versus Curves. When confronted with a lot of figures as in Table IV, one should endeavor by some means or other to present them in a diagram or set of curves. No one can grasp the significance of a complex set of figures from studying the figures

*The data presented here were actually obtained from ten individuals. The individuals have been so selected, however, that the conclusions obtained from these data will agree very closely with similar calculations based on a study of 56 individuals. The averages obtained from 56 men and women are respectively:—242, 159, 137, 120, 114, 99, 94, 86, 88, 83, 79, 76, 74, 74, 70, 70, 68, 64, 64, 63.

themselves with anywhere near the ease that he can from seeing those same figures set forth in curves. In general, curves should be used for discovering or for presenting general relationships, while tables should be used when the facts need to be ascertained very accurately.

First of all, then, plot the ten sets of figures. Two or three curves can be drawn on the same sheet of paper. Use the regular coördinate paper. Count one square as equal to 10 units of your data on your vertical axis, thus giving you a maximum of 500 units. On your horizontal axis indicate a trial at every line. Consider all records over 500 units as equal to 500 and plot them accordingly.

Now from a study of your curves and your table ascertain whether all ten agree or disagree on the following points:—

1. Do they show improvement with practice?
2. Do they show the same initial efficiency?
3. Do they show the same final efficiency?
4. Is a greater gain made during the first five trials than during the last five?
5. Is progress regular or irregular?
6. Do all curves show an equal gain?

Back up each of your assertions with proof from your data.

Second, if we should arrange the ten individuals according to their initial ability in this performance we would have them in this order:— B(76), I(129), J(131), C(210), E(216), A(232), G(283), F(286), D(363), and H(701). Copy this order onto a sheet of paper so that the letters will appear in a column one under the other. Now arrange the ten individuals according to their final ability in this performance in a similar column. Study the relationship between the two columns of letters and then decide whether individuals who are best at the start are best at the end or not. Does your conclusion hold good for all ten or for only the majority? If you have exceptions to your rule, can you explain why there should be these exceptions? Make a further comparison (a) between the order of proficiency at the start and the order at the tenth trial, and (b) between the order at the tenth trial and the order at the last trial.

Do you think that B, who is best at the start and fourth at the end, and I, who was second at the start and third at the end, will do better, equal to, or poorer than D and H in arithmetic, geography, running a grocery store, or driving a plow? Explain. What significance, if any, do you think there is in the superiority of B and I over D and H in this performance? How would G compare in these respects with the four (i. e., B, I, D and H?)

Hand in your report at the next class-hour, written up in the usual manner.

LESSON 22. INTRODUCTION TO THE GENERAL SUBJECT OF INDIVIDUAL DIFFERENCES*

Individuals differ very materially with respect to every human trait. If we compare them with respect to height, or weight, or muscular strength, or lung capacity, or eyesight, or hearing, or color of hair, or spelling ability, or musical ability, or inventive power, or any other trait, we find that they all differ from one another in these respects. When one is at first confronted with all these differences one is very apt to become utterly confused and feel that there is no order at all in this chaos of human differences. The person who is the tallest is not always the heaviest. In fact, he may be very thin and weigh comparatively little. The person who has the best eyesight may have any color of hair and may have very good or very poor hearing. The musician may also be a poet or he may be unable to express himself very clearly in any way except on his musical instrument.

Still as we progress in our study of these differences we come to see that all is not chaos, that there is some system underlying the matter. As yet science has worked out but few of the great laws involved. But a start has been made, and already we have been helped in understanding the peculiarities of our friends and pupils.

There is no more important subject for the teacher in psychology than this subject of individual differences. If we were all alike then teaching would be a comparatively easy subject. We would need to know just the physical, mental, and moral dimensions and requirements of the standard and then devise one set of methods which would fit in every case and inevitably produce good spellers, writers, etc. But people are not alike. And this fact means that no one method will work with every individual. Methods of teaching when applied to certain children will produce the desired result and when applied to other children will produce no result worth while or possibly just the opposite result from that desired. Undoubtedly some of the children who fail in the 4th Grade fail because the wrong methods were applied to them. If other methods had been applied some of these failures would have succeeded but, on the other hand, some of those who succeeded would then have failed. What is needed today is that teachers become expert in understanding the differences in children

*CLASS-HOUR	IN CLASS	WRITE UP	READ
22	Discuss, Lesson 21		Lesson 22
23	Exper. Lesson 23	Lesson 23	

and so be able to apply intelligently varying methods to varying needs. Without doubt the teacher of the future is going to become a diagnostician in much the same way that a physician is. The latter studies symptoms, diagnoses the diseases, prescribes the treatment, and if he is fortunate, directs that treatment until the patient is cured. The teacher of the future will be one who will understand the peculiarities of children and on the basis of these peculiarities or differences, diagnose the reason as to why the child is not developing properly, prescribe the treatment, and carry it out to a successful end. This is exactly what is now being attempted in our special classes for the defective. And altho possibly it is easier to do this with defectives than with normal children, yet society cannot permit the poorest and most worthless one-tenth of our children to have a better type of teaching than that given to the remainder, who will have to carry not only their own burdens, but also a large share of the burdens of the defective class.

Now let us turn and consider such facts and principles as we can discover concerning individual differences.

INDIVIDUAL DIFFERENCES, BASED ON MIRROR-DRAWING EXPERIMENT

It is very clear from a study of the learning curves of the ten individuals recorded in Lesson 21 that they all agree in that:—

1. They show improvement with practice.
2. They make greater gain at the start than at the end of the practice.
3. They progress irregularly, i. e., they do not always advance but sometimes do more poorly than in the preceding trial. We shall find after studying many examples of learning that these three facts remain true. Even tho individuals differ tremendously, yet they do not differ as regards these respects. *Continued practice does produce improvement in a performance in the long run, but it may not be apparent when two or three or even more successive trials are alone compared. Improvement is also greater at the start of practice than at the end.*

On the other hand, individuals differ as regards:—

1. Initial efficiency.
2. Final efficiency.
3. Amount of improvement.

This is clear from the data in Table IV. It will be found to be true when any set of data is studied.

THE USE OF THE AVERAGE AS A MEASURE OF A GROUP

We can obtain an *average* from the records of a large or small number of individuals. Such an average record is given in the last column of Table IV. When we study this average record from ten individuals we realize that it is the best expression possible of the entire ten rec-

ords. But it is not typical of what any one person would do. No one of the ten did the mirror-drawing in 263 units (of time and accuracy combined). The nearest to this record was F, who did the experiment in 286 units, differing thereby from the average by 23 units. On the other hand, B (the best of the ten) beat this average by 187 units, and H (the poorest of the ten) was poorer than the average by 438 units. Clearly a great many interesting facts are covered up or lost by referring to the average as an expression of what this group of ten individuals could do. By knowing only that the group averaged 263 units for its first trial we would have no knowledge of how much the ten had differed or varied from each other.

We have come also to realize that any individual learning curve is not perfectly smooth but has a great variety of fluctuations in it. In other words, altho a person may be progressing, his successive performances may not necessarily show this. Sometimes he gains, sometimes he loses, but on the whole he is advancing. Now our average record of the ten individuals in the mirror-drawing experiment is singularly free from such fluctuations. Only twice does the curve rise and then only for slight amounts. From a study of the average curve we would be led to the false notion that improvement is very steady and even. But such, we realize, is not the case. Evidently, then, the average, altho very useful, is not a sufficient measure of a class performance to tell us all that we need to know about that class.

Consider another example taken from a survey of the Demonstration School of George Peabody College for Teachers.*

All of the children in Grades IV to VIII were tested with the Kansas Silent Reading Test. This test consists of a number of paragraphs like the following:—

NO. 1

VALUE 1.0 — The air near the ceiling of a room is warm, while that on the floor is cold. Two boys are in the room, James on the floor and Harry on a box eight feet high. Which boy has the warmer place?

....

NO. 2

VALUE 1.3 — If gray is darker than white and black is darker than gray, what color of those named in this sentence is lighter than gray?

....

NO. 3

VALUE 1.6 — We can see through glass, so we call it transparent. We cannot see through iron, so we call it opaque. Is black ink opaque, or is it transparent?

....

*C. C. Denny, "The Peabody Demonstration School in the Light of Standard Tests." Unpublished thesis in the library of George Peabody College for Teachers.

The children are allowed five minutes in which to read over as many of these paragraphs as they can and to execute the directions in each. They are scored in terms of the paragraphs to which they have correctly reacted, each paragraph counting proportionately to its determined difficulty or value.

In Table V are presented the average scores of the five grades, together with the *norms* for those grades. A norm is a standard set for a grade after testing thousands of children so as to know exactly what the average is. From these figures it is clear that with respect to this method of testing silent reading the children in the five grades are superior to children thruout the country, as in all the grades except VII the average of the grade is superior to the norm and in Grade VII the figures are equal to the norm.

TABLE V. AVERAGE SCORES AND NORMS, GRADES IV TO VIII

Kansas Silent Reading Scale.

GRADES	IV	V	VI	VII	VIII
AVERAGES	13.0	15.7	16.8	16.5	23.4
NORMS	9.4	13.4	13.8	16.5	19.2

As has been said the scores "show the school to be in most excellent condition." However, if this is all that the class-room teacher is to learn from the test, the very knowledge that should enable her to give her pupils, as individuals, the best possible instruction will have been missed. The scores, in rank order, of all the pupils in the various grades are shown in Table VI. The data given in this table show some astounding individual differences. For instance, the lowest score in the fourth grade is less than one-sixth of the highest score in the same grade; 60% of all the pupils in the fourth grade made a better score than the poorest score in the eighth grade; 17% of all the pupils in the fourth grade made a better score than the norm for the eighth grade; while all the pupils, except six, in the fourth grade made a better score than the lowest score in the seventh grade. In general, the highest score made in each grade is approximately 200% of the norm for that grade; while in three grades, IV, V, and VII, the lowest score is less than half the norm.

"Since reading is fundamental and basic to most of the other studies in the school, this wide variation in individual scores indicates the complexity of the problem confronting the class-room teacher. Why did the poorest fourth grade pupil make only a score of 3.9, and the best one make 24? Is one endowed by nature with six times as much reading power as the other? Did the form and manner of instruction in reading fit one six times as well as the other? Or is the wide difference due to other causes? The facts of Table VI raise innumerable administrative problems. If the school is to be organized so that each indi-

TABLE VI. INDIVIDUAL SCORES BY RANK ORDER, GRADES IV TO VIII

Kansas Silent Reading Test.

	GRADES				
Pupil	IV	V	VI	VII	VIII
1	24.0	28.1	34.6	32.6	34.6
2	21.7	25.4	32.2	28.3	34.6
3	20.3	23.3	26.3	24.1	31.6
4	19.9	22.3	24.0	22.3	31.6
5	19.7	22.3	23.4	21.3	30.3
6	18.4	21.4	22.5	20.7	28.3
7	16.7	21.4	22.3	20.0	27.3
8	16.7	19.7	21.0	19.3	26.3
9	15.5	19.3	20.1	18.5	22.3
10	15.1	18.4	19.1	17.7	21.7
11	15.0	18.3	18.4	17.7	20.7
12	14.8	17.3	18.1	17.7	19.7
13	14.4	17.1	17.5	17.4	18.6
14	13.4	16.1	16.1	17.1	18.4
15	13.1	16.1	14.8	16.1	15.4
16	12.8	15.8	14.8	15.8	13.8
17	12.8	15.4	14.4	15.7	13.0
18	12.5	13.4	14.4	15.1	12.3
19	11.3	13.4	14.3	14.1	
20	11.2	12.9	13.8	13.2	
21	10.4	12.6	13.5	11.5	
22	9.0	12.4	13.4	11.2	
23	9.0	12.4	13.2	10.6	
24	8.9	12.2	12.8	10.6	
25	6.2	11.7	11.1	8.8	
26	6.2	10.6	10.9	8.8	
27	6.2	10.6	10.7	8.8	
28	6.2	8.9	9.1	8.1	
29	5.7	8.7	8.5		
30	3.9	8.5	8.4		
31		8.5	8.1		
32		6.3			
Average	13.0	15.7	16.8	16.5	23.4

vidual pupil may get maximal good from the instruction given, teacher, principal, superintendent, school board, and community must realize this wide variation and coöperate in the organization and administration of a system which takes individual differences into consideration."

THE USE OF THE A. D. AS A MEASURE OF INDIVIDUAL DIFFERENCES.

We have seen thus far that the average is not a sufficient measure for presenting the proficiency of a group of individuals. And in Lesson 20 some of the advantages of the average deviation were presented. The subject warrants further consideration.

The average of the initial trials in the case of the ten individuals recorded in Table IV is 263; the average deviation is 118. The average of the final trials is 55 and the average deviation 12. Knowing the A. D. as well as the average for the initial and final trials in the mirror-drawing experiment we can readily determine, if we do not have the

original data, that there was a very great variation in the individuals at the start, and still considerable difference in their proficiency at the end of the practice. We know that the ten individuals differed on the average 118 units from the average of 263 units. We know now for certain that the average does not represent what all ten individuals did. Far from it. Some must have varied above and below 263 by more than 118 in order that the average of all the deviations should be 118. On the other hand we can tell, by knowing that the final trial averaged 55 with an A. D. of 12, that the ten must all be fairly close to the average, probably none varying more than three times the A. D. or by more than 36. That is, no record would probably be better than 19(55—36) or poorer than 91(55+36). (As an actual fact among 56 men and women the best record has been 33(55—2 times the A. D.) and the poorest was 118(55+5 times the A. D.) But there are only two records in the 56 which are poorer than three times the A. D., (i. e., 91)—one being the 118 already referred to and the other being 93).

In a similar way the A. D. may be determined for the data in Table VI concerning the silent reading ability of children in the five grades. We then have:—

Av. Score, Silent Reading.	Grade IV	13.0	A. D.	4.2
" "	" V.	15.7	"	4.5
" "	" VI.	16.8	"	5.3
" "	" VII.	16.5	"	4.5
" "	" VIII.	23.4	"	6.4

The presence of these average deviations helps us considerably in estimating how much the various children in the two classes differ from their average.

The more one uses this measure—the A. D.—the more it comes to mean; but still it never does tell as much as one can tell from the original data themselves when displayed in table form as in Table VI.

RELATIONSHIP OF INITIAL AND FINAL ABILITY.

When the ten individuals are arranged in "order of merit" according to initial and final ability it is clear that on the whole those who are best at the start are best at the end. G is markedly an exception to the rule, starting at sixth place and ending first. H also gains four places, progressing from tenth to sixth place. G was actually a student of markedly superior ability, but noted for awkwardness of movement. He tackled the experiment with misgivings of his ability to do it, thinking it was largely a feat of arm movement. He learned very rapidly and surprised himself with his performance.

Knowing nothing of these ten individuals but their initial scores, it would be safer to hire the first two to work in a store or on a farm, or to gamble on their scholastic record that on the last two. This is true,

because the test does measure general ability to some extent. But because the test is far from a perfect measure of ability, individuals hired on the basis of it would not always come up to expectations. This we see in the case of G, who, on the basis of the final score, is better than either B or I.

LESSON 23.—HOW DO DIFFERENT GROUPS OF INDIVIDUALS DIFFER WITH RESPECT TO THEIR LEARNING SIMPLE ARITHMETICAL COMBINATIONS?

In Lessons 21 and 22 we made a preliminary study of individual differences as displayed in mirror-drawing. In this lesson we shall devote our attention to how individuals differ in the simplest processes of arithmetic, i. e., simple addition and simple multiplication. Some of the questions involved are:—How do I differ from other adults in a working knowledge of the multiplication table? Am I more or less rapid in my work than the average adult? Am I more or less accurate than the average adult? How do adults differ from children in these respects? How do children differ among themselves? Besides ascertaining some of the facts in these cases, we shall commence to ask ourselves the further question,—what is the cause of these differences?

First of all the members of the laboratory section will use the B-Test blank, on which appears eighty simple problems in addition, such as $\begin{array}{r}4\\7\\\hline\end{array}$ $\begin{array}{r}1\\3\\\hline\end{array}$, etc. The class will be given one minute in which to do as many of these problems as they can do. After that the class will be tested as to their proficiency in multiplication, using the BX-Test blank. The papers will then be scored and the averages and average deviations of the two tests worked out for the class. When that is finished the laboratory pairs will proceed as usual by themselves, taking up the various parts of the assignment in order and doing as much as they can during the remainder of the hour. As each part is finished it will be advisable for the members of the class to consult with the laboratory instructor in order to make sure that they have understood the instructions and have executed them properly.

PART I. PROBLEM. HOW DO ADULTS DIFFER AS TO THEIR ABILITY TO SOLVE SIMPLE ADDITION AND MULTIPLICATION PROBLEMS?

Apparatus. A B-Test and a BX-Test Blank, watch.

Procedure. When all in the laboratory section are ready, turn face down the page on which the B-Test is given. The instructor will give two signals, "Get Ready," and "Go." At the latter signal, turn the

sheet over and solve as many problems as you can during the one minute allowed you. At the signal, "Stop," *stop* your work wherever you are and hold up your right hand, so that the instructor can have visible proof that you have actually stopped. (These instructions you will undoubtedly have cause to use later on yourself, as a teacher. You now have an opportunity to know how it feels to take a test of this sort.)

Trade papers with some other member of the class. The instructor will then call out the correct answers to the addition problems. Every mistake on the paper before you should be indicated by drawing a conspicuous circle around it. Indicate at the top of the page the total number of problems performed, the number incorrect, and the number correct. A convenient form for doing this is, "65—3=62," or "60—0=60," where the first number indicates the number performed, the second the number wrong, and the third the number correct.

Return the papers to their owners, who then may look them over to see if they have been corrected properly. In case of a controversy the scorer should be the final judge. Ambiguously written figures should be scored against.

Repeat the above with the BX-Test blank to test ability in simple multiplication.

Results. The instructor will now record the data of the two tests on the board and with the aid of the class determine the averages and average deviations of the class. Any errors characteristic of the class should also be recorded.

Interpretation and Application. Combine into one general discussion at the close of your report the interpretations and applications to this problem and those that follow.

B TEST—ADDITION

Name........................Age...........Grade..........

3	0	3	10	12	9	7	6	4	2
11	8	2	7	4	0	8	5	8	1
8	5	8	12	6	9	2	11	12	0
12	1	0	5	10	5	10	3	1	7
1	10	4	9	6	7	12	1	7	6
8	7	12	1	6	3	9	4	12	1
7	6	4	9	10	2	1	10	8	5
2	11	7	6	3	6	9	6	3	10
3	8	4	5	6	3	7	10	8	0
3	4	10	11	3	2	5	3	5	6
11	7	0	9	11	4	8	5	8	6
4	7	11	10	11	0	8	4	9	7
3	10	3	0	12	1	9	1	4	5
12	1	7	2	8	5	9	0	9	0
12	5	2	11	2	0	2	4	10	2
11	9	2	8	5	12	11	4	11	9

BX-TEST—MULTIPLICATION

Name.........................Age............Grade..........

3	0	3	11	12	9	7	6	4	2
11	8	2	7	4	0	8	5	8	1
8	5	8	12	6	9	2	11	12	0
12	1	0	5	10	5	10	3	1	7
1	10	4	9	6	7	12	1	7	6
8	7	12	1	6	3	9	4	12	1
7	6	4	9	10	2	1	10	8	5
2	11	7	6	3	6	9	6	3	10
0	8	10	7	3	6	5	4	8	3
3	4	10	11	3	2	5	3	5	6
11	7	0	9	11	4	8	5	8	6
4	7	11	10	11	0	8	4	9	7
3	10	3	0	12	1	9	1	4	5
12	1	7	2	8	5	9	0	9	0
12	5	2	11	2	0	2	4	10	2
11	9	2	8	5	12	1	4	11	9

PART 2—PROBLEM. HOW DO ADULTS DIFFER FROM 4TH GRADE CHILDREN IN THEIR ABILITY TO SOLVE SIMPLE MULPLICATION AND ADDITION PROBLEMS?

Apparatus. The data in Table VII.

TABLE VII. SHOWING AVERAGE NUMBER OF ADDITION AND MULTIPLICATION PROBLEMS SOLVED CORRECTLY IN ONE MINUTE BY ADULTS AND 4TH GRADE CHILDREN IN 10 (AND 14) TRIALS ON DIFFERENT DAYS.

	ADDITION (B-Test)		MULTIPLICATION (BX-Test)	
Trials	Adults	4th Grade Children	Adults	4th Grade Children
1	59	19	40	11
2	67	21	50	15
3	69	22	52	16
4	69	23	55	17
5	71	25	58	19
6	72	26	61	20
7	74	27	61	21
8	75	28	62	21
9	75	29	64	23
10	76	30	64	24
11		31		25
12		32		26
13		32		27
14		33		28

Note: The children were allowed two minutes instead of one minute to work at the blank. Their records are expressed in terms of what they did in 1 minute i. e., half of their 2-minute record.

Procedure and Results. Plot these data. Arrange your vertical scale so that it will extend from 0 to 80. Connect the points on the addition curves with a solid line, and the points on the multiplication curves with a dotted line.

PART 3—PROBLEM. HOW DO NORMAL 4TH GRADE CHILDREN DIFFER FROM BADLY RETARDED CHILDREN OF THE SAME AGE IN THEIR ABILITY TO SOLVE SIMPLE ADDITION PROBLEMS?

Apparatus. The data in Table VII and the following information:—A class of 2B Grade children were tested by Miss M. Phillips with the B-Test. These children averaged 9½ years, (just what our 4th Grade averages). They had repeated the work of the first and second grades several times and were considered by the authorities to be practically hopeless. They were put (1) thru the B-Test on ten successive days; (2) thru the C-Test (identical to the B-Test except for the combinations which were new) on ten more days; (3) given 10 minutes drill on 15 successive days on the problems of the B-Test; and (4) again given the B-Test for 10 successive days. Parts (2) and (3) represent 170 minutes drill devoted to simple addition problems distributed over 25 days. The average records of the class in parts (1) and (4) with the B-Test are as follows:—

Trials	Part 1	Part 4
1	4	7
2	5	8
3	5	8
4	5	9
5	6	9
6	6	10
7	6	10
8	6	10
9	7	11
10	7	11

Procedure, Etc. Handle these data as in Part 2. Bear in mind that the averages (i. e., *norms*) for the Demonstration School and for adults were as follows:—

GRADES	NORMS IN ADDITION (*B-Test*)		NORMS IN MULTIPLICATION (*BX-Test*)	
	Oct., 1915	Feb., 1917	Oct., 1915	Feb., 1917
III	—	15	—	6
IV	19	29	11	20
V	26	37	17	26
VI	—	40	—	25
VII	18	44	27	27
VIII	20	43	30	30
IX	—	49	—	30
Adults	59	59	40	40

The differences in the norms on the two different dates is due, first to the fact that in the second case the grades had had three months more schooling by February than in October and, second, to the fact that during the interval a considerable amount of time was spent in the school speeding the children up. That this was very much needed is clearly apparent from the figures. In justice to the Demonstration School it should be noted here that the first set of norms was taken very shortly after the opening of the school and the poor work represented the training these children had received prior to entering the school.

Procedure and Results. Plot the learning curves of the mentally defective children on the same graph as your other curves.

Note: In these experiments the same blank was used each day. Some of the learning consists in more or less learning of answers in a regular order. If a different arrangement of the little problems had been presented each time, the curves would not have gone up so rapidly.

Interpretation of the three parts to this problem. What do you deduce as to how various classes of individuals differ with respect to learning simple addition and multiplication combinations? Have these three groups of individuals become more or less alike as the result of ten days' practice? What effect has this fact upon our present plan of school administration?

Application. Hand in your report at the next class-hour.

LESSON 24. THE THREE CAUSES OF INDIVIDUAL DIFFERENCES—ENVIRONMENT, HEREDITY, AND TRAINING*

We have noted already that all individuals are alike in that they profit by practice; that they show greater gain at the beginning of practice than at any later time; and that the rate of improvement is irregular, an individual showing remarkable gains with certain trials and equally surprising "slumps" with other trials. We have also noted that individuals do differ as to (1) initial performance, (2) final performance, and (3) the amount of improvement resulting from any given amount of practice. Let us now consider these differences in greater detail.

ENVIRONMENT, HEREDITY AND TRAINING

A human being may be thought of, first of all, as being produced by the two factors—*heredity* and *environment*. He is a living organism that *reacts* to the *situations* that confront him in life. The situations (environment) are the immediate cause of his reactions—*they initiate the reaction but they do not condition that reaction.* In other words, the environment brings about reactions but what those reactions are are determined by the laws of the organism itself. What a person does during any day of his life is determined by his environment, then, and by his innate life. If it is summer time and there is a swimming hole in the vicinity, he may or may not go swimming. If there is no other factor in his environment, such as a dance, to lead him to do otherwise, he quite likely will go swimming. Yet he may not. Some individuals do not respond to swimming situations by going in swimming. Their natures are so constituted that they do not receive pleasure from such experience and so do not seek it. One of the writer's boyhood friends —the best pitcher in town—never went swimming. He didn't enjoy it. Take another example from real life. A German boy, the son of a brewer, living in a German community, never drank beer. Such a situation, as confronted him daily, would lead most individuals to drink beer. But he didn't. He did not like it, so he didn't drink. In the Holmgren test for color blindness one is given a hundred or more different colored skeins of yarn. He is then given a large skein of red yarn and told to pick out all the little skeins of similar color. The ordinary individual picks out only red skeins. But a color-blind person picks out not only red but also brown and gray skeins. And if there

*CLASS-HOUR	IN CLASS	WRITE UP	READ
24	Discuss, Lesson 23		Lesson 24
25	Exper. Lesson 25	Lesson 25	

happens to be a green skein of the same brightness as his red standard he will pick this out also. The same situation leads to two quite different reactions here. The reactions are different because of the difference in the development of the eyes of the two individuals. The eyes of one individual are so constituted that red and green are distinguished apart; the eyes of the other individual are so constituted that red, gray, and brown, and even a green, with the correct brightness appear alike. We may say then again, that the situation (environment) is the cause of a reaction, but the innate make-up of the individual (heredity) determines just what the reaction shall be.

In the case of our mirror-drawing experiment, the situation was the same for all ten individuals, but their reactions differed very materially. Some were very accurate and quick in reacting, some were accurate and slow, some were inaccurate but quick, and some were inaccurate and slow. At first thought we might imagine that the individual differences in this experiment were all due to heredity, since the situation was alike for the ten individuals. But such a statement is not so exact as we shall desire here. Suppose one of the ten individuals had practiced with the apparatus at some previous time. Would it then be fair to say that he did better than the others simply because of heredity? Certainly not. We must then introduce a third factor into the discussion—the factor *of training*. Training may be thought of in this connection as the habits the individual has accumulated from previous experiences in life. Every time we react to a situation we add a new element to our mental make-up. And so we may think of ourselves as being made up of pure hereditary influences plus habitual influences. How we react, then, toward the swimming hole situation is dependent (1) upon the entire situation comprising swimming hole, dancing possibilities, etc.; (2) upon our original nature given us by heredity, and (3) upon the sum total of our experiences in life, our training. This factor of training is, of course, a mixture of heredity and previous environment which now affects the organism's reaction to his immediate environment.

Consider the case of a baby who has commenced to talk and already knows a "goose" but no other bird, and the word "dress" but none other to designate clothing. Standing on the porch one day, she observes a pigeon up above her preening its feathers. Finally a feather drops out and flutters to her feet. She picks it up and holding it out to her mother to admire, exclaims, "Goose's dress." The reaction, "Goose's dress," is then initiated by the feather falling at her feet. Original nature is responsible for her responding to the small object by picking it up, also by desiring to talk about it. But previous

training determines that the particular words that are used are words already learned. All three factors contribute then to the reaction. *What we do at any moment in life is due to the interplay of these three factors: (1) the situation confronting us—(2) our own original nature inherited from our ancestors, and (3) our own acquired habits, the result of previous experiences.*

Before considering the indivdual differences which we have discovered in the mirror-drawing experiment, or the simple arithmetical work, in the light of these three factors, one point needs to be cleared up which may puzzle some.

LEARNING CURVES BASED ON "TIME" VERSUS THOSE BASED ON "AMOUNT DONE."

In the mirror-drawing learning curves, as one progressed, his curve came down; in the arithmetic test, as one improved, his curve went up. This difference is due to the fact that in the mirror-drawing experiment the results were recorded in terms of *time* (seconds), while in the arithmetic tests the results were recorded in terms of *amount done.* Improvement shows itself either by a decrease in time for doing

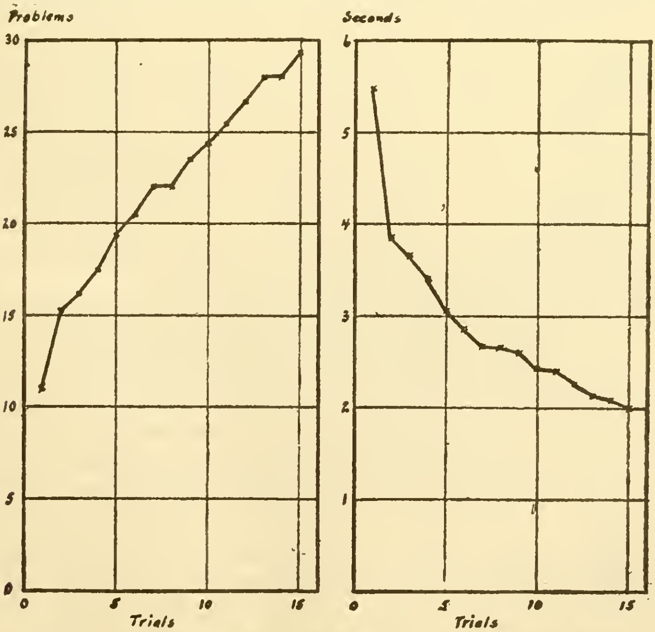

Plate VII. Learning curves of 4th grade children in multiplication. The left hand curve shows the number of problems solved in two minutes on 15 different days. The right hand curve shows the average time required to do a single problem on the 15 different days. The former records progress in amount done, the latter in time consumed.

the same task (as in the mirror-drawing experiment) or by an increase in what is accomplished in the same work-period (as in the arithmetic tests). Now either of these curves can be transmuted so as to appear in the other form. Take, for example, the curve of learning of the 4th Grade children in multiplication (shown in the left hand curve of Plate VII). Here we see that the children performed 11 problems correctly on the first occasion, 15.5 problems on the second, etc. They accomplished that much in 60 seconds. At that rate it required 5.5 seconds to do one problem on the first occasion (i. e., $60 \div 11 = 5.5$); 3.9 seconds to do one problem on the second occasion (i. e., $60 \div 15.5 = 3.9$); etc. When these quotients are plotted for the trials we obtain the right hand curve in Plate VII. The two curves, then, both record the same facts, altho one goes up and the other comes down. With a little practice in thinking in terms of curves this seeming paradox will no longer bother one.

EXPLANATION OF INDIVIDUAL DIFFERENCES IN TERMS OF "HEREDITY" AND "TRAINING."

In the case of the mirror-drawing experiment, or the simple arithmetical work, the situation is the same for all the individuals. All the individuals are confronted with the same apparatus or the same blank of 80 problems. In one sense this is not strictly true, as we have already seen, since different individuals respond to different details in the entire situation. But these differences are not due to actual physical differences in the situation, but rather to differences in the individuals themselves. We may then properly speak of the situations confronting the individuals as being exactly the same in all ten cases. It then remains to explain the differences we find among the ten individuals in terms of "original nature" or "training."

The Effect of Previous Training. We have learned that all individuals show greater improvement at the commencement of practice than at the end. This being the case *the learning curves of those who have had no previous practice will rise more rapidly and slow up more gradually than in the case of those who have had previous practice.*

This fact may be illustrated in Plate VIII by saying that the person who has had no previous practice (training) would have the learning curve marked B. The person with previous training might have instead a curve similar to A. The former's curve would show very marked gains at the start and would show a large improvement altogether. The latter's curve would not show such a marked gain at the start and would not show such a large total improvement. We may think of A's curve as not being complete—that the first 15 trials are not shown here (having been performed before) and that what is

represented is trials 16 to 41. This is on the assumption that A and B are exactly identical in every respect. This is further shown in the two curves by representing B's progress in trials 16 to 26 as exactly

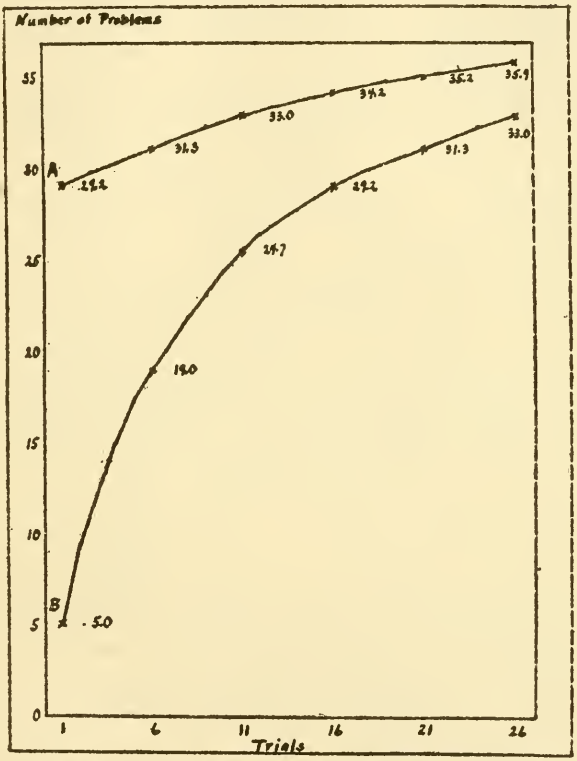

Plate VIII. Showing learning curves of two individuals who are identical in all respects save in the amount of training in the arithmetical combinations.

equal to A's progress in trials 1 to 11. And if the curves were continued, B's progress in trials 26 to 41 would be identical to A's records in trials 11 to 26. *Previous training, then affects an individual's learning curve by raising its starting-point and by eliminating to some extent at least the ordinary big rise at the start.*

It was stated above that B would show *apparently* greater improvement than A. The word "apparently" should be emphasized. Plate VIII is so drawn as to indicate that altho B's curve shows a greater gain than A's curve when measured in terms of improvement in problems performed correctly (i. e., 5 problems to 33.0 problems as against

29.2 problems to 35.9 problems) yet in terms of number of trials B has not gained over A. He started out 15 trials behind and remained 15 trials behind to the end. If B's curve were extended for 15 trials more it would then reach the point reached by A at his 41st trial—the end of his practice period. It is an extremely difficult matter to measure relative improvement in terms of time or amount of work done, because as one approaches his limit each unit of effort will produce a smaller and smaller gain in time saved or work accomplished.[1]

The Effect of Differences in Hereditary Endowment. How do differences in sheer hereditary endowment affect learning curves? Plate IX illustrates this point. The individual with the best endowment will show the greatest improvement, the person with the least endowment will show the least improvement. Curves B, C, and D represent the learning curves of three persons; curve B being the curve of the best endowed, curve C being of a poorer endowed person, and curve D being of the poorest endowed person of the three. *The better the original nature of the individual the greater will be the improvement resulting from practice.* These three individuals with equal training and varying degrees of hereditary endowment would not even do equally well, of course, on the first trial, because the better endowed person would do better than the others right from the start.

One warning should be given here. The degree of efficiency of the original nature of the individual must be considered as it applies to the particular task being tested. For example, a great musician (having superior original nature in musical lines) may not necessarily have superior endowment in mirror-drawing. The musician's curve in mirror-drawing will show great improvement or not; depending not upon endowment in general, but upon the endowment which he has that pertains to mirror-drawing.

The Effect of Differences in Training and Heredity Combined. Now let us consider, third, some combinations of these two factors. We may have four individuals, (1) A having good heredity and previous training, (2) B having good heredity but no previous training, (3) E having poor heredity and previous training, and (4) D having poor heredity and no previous training. (Poor heredity is to be understood as endowment having to do with the trait under discussion; training to be considered in terms of so many units of time devoted to learning specific material.) Then their learning curves would take more or less the forms illustrated in Plate X. A and E can be thought of as having had 15 units of instruction, and B and D as having had

(1) This point is discussed further in the writer's monograph, Effects of Hookworm Disease on the Mental and Physical Development of Children. International Health Commission, 1916, pp. 22-39.

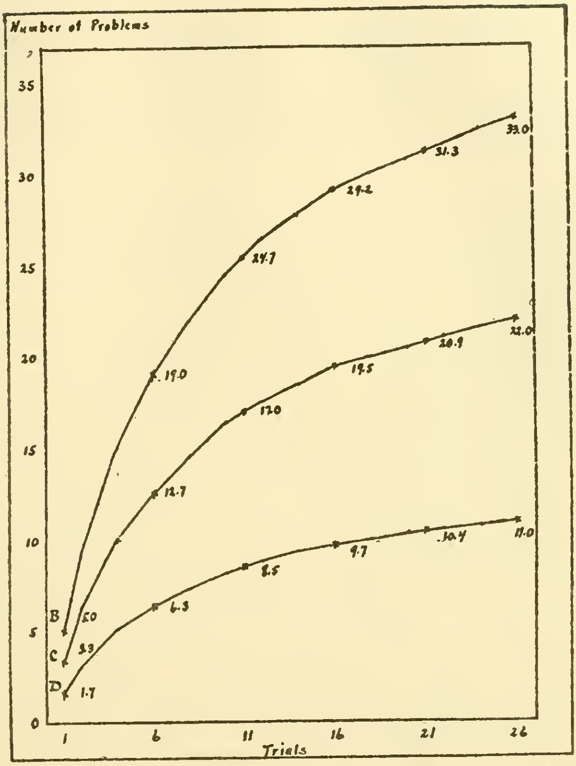

Plate IX. Showing learning curves of three individuals with different hereditary endowments.

none. As B is superior to D by hereditary endowment he will do better than the latter at the start and will rapidly leave him behind. (See Plate IX, where this point is alone considered.) The more training they receive the more different will they become as far as this trait is considered, because of the difference in their ability. In the same way A and E, who have had some previous training become more and more unlike as they continue their training. These curves illustrate, then, the principle that continued training makes individuals of different hereditary endowment more and more unlike. We shall return to this point a little later.

The curves of A and B are symmetrical. A's curve actually being the same as B's from the latter's 16th trial on to what would be his 41st trial. The curves of E and D are also symmetrical in the same way. Because of their previous training A and E will maintain their supe-

riority over B and D, respectively. This superiority seemingly grows smaller and smaller with practice. It actually does if measured in terms of problems performed, but it does not if measured in terms of effort, for A always remains ahead of B to the extent of what 15 units of time will produce, and likewise E remains ahead of D to that extent.

The difference between the good heredity of A and B and the poor heredity of E and D is meant to be a considerable difference. Yet it is not exaggerated at all in comparison with the differences found in most any class room. The differences between the average of the 4th Grade and the group of retarded children is about equal to that shown here between A and E. In Plate XI are shown the curves of a child from the 4th Grade and another from the retarded group. The former is not the brightest in that grade (actually rated 11th in a class of 28) and the latter is not the dullest among these unfortunate children. The retarded child's record was, 0 problems, 0, 0, 0, 1, 0, 1, 2, 2, 2, and after 170 minutes drill, 5, 5, and 4. Here measles intervened to spoil our record. In fairness to the records it should be stated that undoubtedly the 4th Grade child practiced on these combinations outside of school. But the dull child had also this opportunity. The curves do represent consequently the learning that followed equal stimulations in the school. One child could respond in an adequate manner and did so and the other child could not and so did not. Some children can learn mathematics so that they eventually master calculus and its applications to engineering, while others never get beyond the fundamentals. Some children master the principles of art and design and become skilled in dressmaking, millinery, architecture, painting, etc., while others are oblivious to the most atrocious combinations of color or form in their clothes, their home surroundings, etc. The gifted child learns rapidly and improves tremendously, the child who is lacking learns slowly and learns very little.

INDIVIDUAL DIFFERENCES IN SOLVING SIMPLE ARITHMETICAL COMBINATIONS.

Let us now more or less review what has been discussed in this lesson but consider the matter in terms of the data studied in Lesson 23. These data are plotted in Plate XII. The curves do not bring out the points so clearly as do the theoretically constructed curves of Plates VIII, IX, and X. Nevertheless they bear witness to all of those points.

1. *The greater the amount of practice the higher the curves start.* This point needs no further discussion.

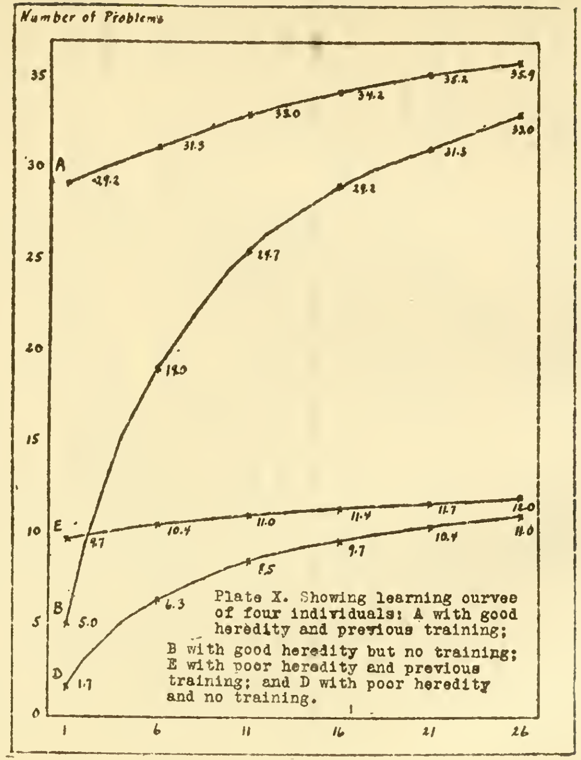

Plate X. Showing learning curves of four individuals: A with good heredity and previous training; B with good heredity but no training; E with poor heredity and previous training; and D with poor heredity and no training.

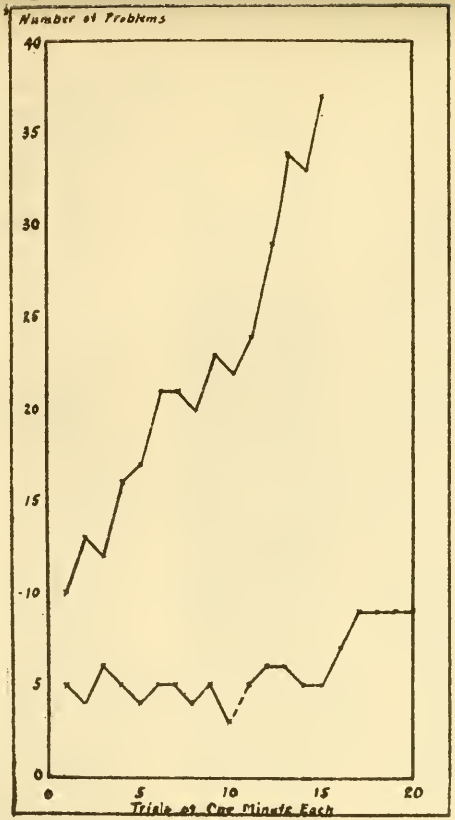

Plate XI. Showing learning curve in solving addition combinations (B-Test) for a bright 4th grade child and a mentally defective child of the same age. (In the case of the latter between trials 10 and 11 there intervened 170 minutes of drill extending over 25 days on addition combinations.)

2. *The greater the amount of practice the less rapid the gain.* This point is true but it does not always appear, due to the presence of conflicting factors. Altho none of these groups had had any previous training with the particular tests under discussion, yet we naturally would expect the adults to have had more practice and so to show less improvement than the 4th Grade children. The real cause, however, as to why the curves do not clearly illustrate the point made at the commencement of this paragraph is due to the differences in the groups in terms of heredity. Not only are the adults superior to the 4th Grade children because they have a mature development of their hereditary nature, but also without question a class of college men and women are superior to a class of 4th Grade children. That is, the 4th Grade class will not average as high an endowment when they become adults as do the college students. This class of 43 college students is probably composed of the brightest students from 43 4th Grade classes. The great differences in heredity cover up then the effect of much practice versus little practice.

3. *The greater the hereditary endowment the greater the improvement from training.* This point is clear from the curves and from what has just been stated.

4. *The greater the training the more a group of individuals become unlike.* At the commencement of the training recorded here the three groups could perform as follows:

College students solve	59 problems per minute.
4th Grade Children solve	19 problems per minute.
Defective Children solve	4 problems per minute.
Average	27.3
A. D.	21.1

and at the end of ten practice periods they performed as follows:—

College students solve	76 problems per minute.
4th Grade children solve	30 problems per minute.
Defective Children solve	7 problems per minute.
Average	37.7
A. D.	25.6

As the A. D. has increased we know the groups are less alike than before. This fact is shown also in this way.

College students are superior to 4th Grade Children at start by 40 problems.

College students are superior to 4th Grade Children at end by 46 problems.

Plate XII. Showing learning curves in solving simple arithmetical combinations from adults, Curve A (B-Test) and Curve B (BX-Test): 4th grade children, Curve C (B-Test) and Curve D (BX-Test): and from defective children, Curves E and F (B Test,--Curve F prior to and Curve E after 170 minutes of special drill on addition combinations.)

Also—

College students are superior to Defective Children at start by 55 problems.

College students are superior to Defective Children at end by 69 problems.

and—

4th Grade Children are superior to Defective Children at start by 15 problems.

4th Grade Children are superior to Defective Children at end by 23 problems.

This fourth fact, that training causes a group to "fly apart," to become more and more unlike, due to the inherent differences in the hereditary equipment of the members of the group, affects our school work most profoundly. It makes clear that no grade can be taught as a class without some members very shortly doing such good work as to tempt the authorities to promote them into the next grade and some other children doing such poor work as to lead to their being put back into the grade below or to force the teacher to give them individual instruction. No mechanical administrative scheme for holding a class together will ever work satisfactorily because the members of that class cannot advance at the same rate. The solution to this difficulty has not been evolved, but if it ever is, in the writer's opinion, it will include a very flexible scheme of promotion by subject-matter, coupled with extensive provision for individual coaching of children that are markedly behind and markedly ahead of their class. This point will be taken up again later. But right now it should be realized that the main point of the whole problem is that children cannot progress in their learning at the same rate:—that some go fast, some go slow, and some advance at average speed.

LESSON 25. THE GENERAL LAW AS TO HOW INDIVIDUALS DIFFER

We know that people are different almost before we realize that there are people. We distinguish between tall people and short people, fat people and thin people, clever people and silly people, and most of us would agree fairly well in our classifications. But how do we draw these distinctions? Do we have hard and fast lines, enclosed between which one class is set off from another? Should we say that all men between 0 inches and 62 inches in height, for instance, are short, and those between 62 inches and 84 inches are tall? Or that any one less than 125 lbs. is thin and anyone more than 125 lbs. is fat? And even if we decide to be so definite in these cases, (tho certainly our standard is artificial) where shall we draw the line in the case of mental attainments? Are we all talented or stupid for example? Or are most of us merely average people without special qualifying adjectives, and the rest of us simply either better or worse than the average? That is, instead of having separate little groups of idiots, normal folks, and geniuses, the members of each class keeping carefully to themselves, do we perhaps have but one class of individuals, all typified by the average, yet all varying from the average in greater or less degree?

We are about to perform an experiment in throwing dice. This is as purely a chance performance as we can get. Let us see if the

Number of Throws

8															
6							24								
							19								
4							14								
					18	22	8	17							
2					15	11	5	13	16		12				
			21	25	1	6	4	2	10	7	3	20	9	23	
	4		6		8		10		12		14		16		18

Total Amount of Throws.

Plate XIII. Illustrating by means of a "surface of distribution" twenty-five throws of three dice.

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throws are distinctly different or whether they follow one general law. For example, can we divide the throws into two groups—high and low, or must we think in terms of one group with variations from its average? In any case the results may apply to our biological problem as given above.

THE EXPERIMENT.

Problem. In throwing dice are the totals distinctly different or do they approach a general type?

Apparatus. Coördinate paper; 3 dice.

Procedure. Part 1. Lay off on your coördinate paper a base line, and number the squares from 0 to 20, as is done in Plate XIII. Lay off a vertical axis and number the squares from 0 to 35. Now commence and throw your three dice. Count up the total of the three dice and record that total on your coördinate paper in its proper place. (The writer threw first a 4, 3, and 1, making a total of 8. A little square was then drawn as indicated by the 1 in Plate XIII. An 11 was thrown next and it is indicated by the 2 in the Plate. A 14 was thrown third, etc. Twenty-five throws are indicated in this Plate, the twenty-fifth throw being a 7. Plate XIII shows then that the writer threw

one	6	two	12s
one	7	one	13
three	8s	two	14s
three	9s	one	15
six	10s	one	16, and
three	11s	one	17.

Thus 25 throws are distributed or indicated in the plate.

Record in this way 100 throws. Show your completed diagram to the instructor before proceeding further.

Such a diagram is called a *surface of distribution* as it shows just how all the throws were distributed among the possible totals.

Part 2. Now determine how many different totals can be obtained by throwing three dice. (In Plate XIII are indicated 12 different totals, i. e., from a total of 6 to a total of 17, inclusive.) Present your answer to your instructor before proceeding further.

Part 3. Now figure out (a) all the possible different combinations* it is possible to obtain by throwing three dice.

(This assignment is independent of Part 1 and can be worked out without any reference to it). The writer threw first a 4, 3, and 1; next time he threw a 3, 5, and 1; the third he threw a 6, 5, and 3. Here are three different combinations. The question is, how many different combinations are there? (Consider in this connection that a throw of 4, 3, and 2 is different from a 2, 4, and 3, and both of these are different from a 3, 2, and 4.)

Also figure out (b) how many of each total you will obtain when every possible combination is considered. (For example, throws of 2, 4, and 6; 5, 5, and 2; 5, 6, and 1; are three different combinations, but they all give the same total, i. e., 12.) In Plate XIII are indicated 12 different totals, i. e., from a total of 6 to a total of 17, inclusive. On the preceding page are listed how many of each of these totals the writer obtained in his 25 throws.

Part 4. Suppose instead of getting the 100 throws you did get, you had thrown the dice as many times as there are different combinations and in throwing the dice that number of times had got each and all of these different combinations. Plot a surface of distribution to illustrate just this.

Part 5. What relation do you think there exists between the surface of distribution you actually obtained by throwing the dice 100 times and the surface of distribution obtained in the preceding paragraph?

What relation do you think there exists between the findings in this experiment of throwing dice and the general problem of how individuals differ? Can throws be divided into two or more groups; can individuals?

Hand in your report at the next class-hour.

*Mathematically speaking what is wanted here is permutations, not combinations, That is, in forming combinations we are only concerned with the number of things each selection contains, whereas in forming permutations, we have also to consider the order of the things which make up each arrangement; for instance, if from six numbers, 1, 2, 3, 4, 5, 6, we make a selection of three, such as 123, this single combination admits of being arranged in the following ways:—123, 132, 213, 231, 312, and 321, and so gives rise to six different permutations.

LESSON 26.—GENERAL LAW AS TO HOW INDIVIDUALS DIFFER*

THE NORMAL SURFACE OF DISTRIBUTION.

If one should take three dice and throw them 216 times, each time counting up the total score and plotting this score, one might obtain a surface of distribution somewhat like the three surfaces shown in Plate XIV. The first and third were actually so obtained, the middle one is the perfect surface which chance theoretically should give.

One may figure out this theoretically perfect surface in this way. Count up all the throws that are possible and record how many times each total appears. You may have

1	and	1	and	1,	a total of	3
1	"	1	"	2,	"	4
1	"	1	"	3,	"	5
1	"	1	"	4,	"	6
1	"	1	"	5,	"	7
1	"	1	"	6,	"	8
1	"	2	"	1,	"	4
1	"	2	"	2,	"	5

etc.

When you have so obtained all the 216 totals you will find that you have

1	total of	3	27	"	11
3	totals of	4	25	"	12
6	"	5	21	"	13
10	"	6	15	"	14
15	"	7	10	"	15
21	"	8	6	"	16
25	"	9	3	"	17
27	"	10	1	"	18

When these data are plotted you have the ideal surface of distribution in Plate XIV. All this means that when you throw three dice you are just as likely to get any one combination as any other. But you are more likely to get a total of 10 or 11 than 3 or 18. You can express this likelihood by the expression 27 to 1, for there are 27 combinations that will give a total of 10 or 11, whereas there is only one combination that will give 3 or 18. Our normal curve of distribution represents then that surface most likely to be obtained by 216 throws. Actually we seldom get exactly that ideal surface, but we do get surfaces that approximate it in general appearance.

*CLASS-HOUR	IN CLASS	WRITE UP	READ
26	Discuss, Lesson 25		Lesson 26
27	Exper., Lesson 27	Lesson 27	

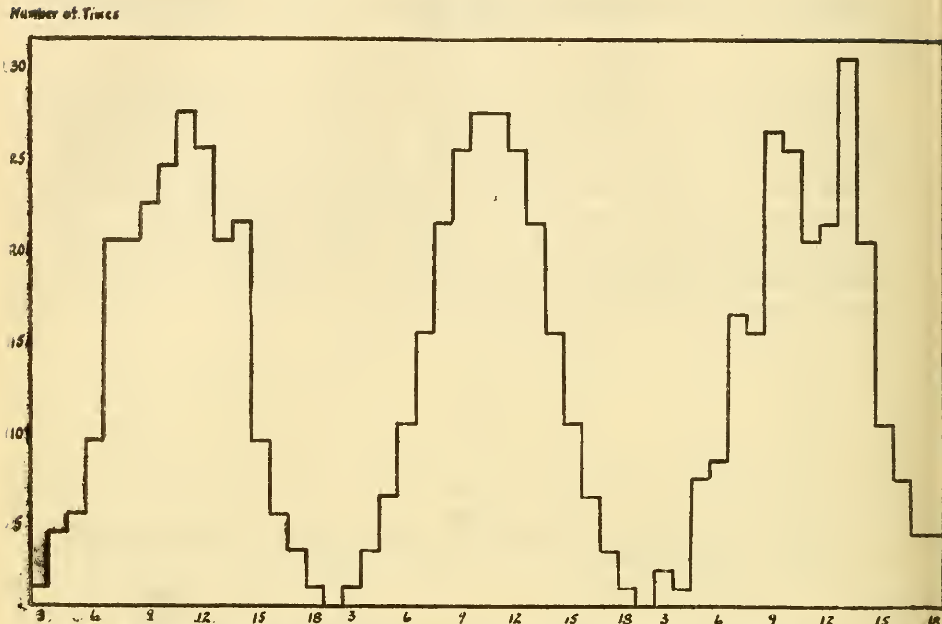


Plate XIV. Three surfaces of distribution obtained from throwing three dice 216 times. The first and third surfaces were obtained from 216 actual throws. The second is based on what theoretically should be obtained from that number of throws.

One may think of this matter of throwing three dice as being conditioned on three independent factors, each one of which may vary independently in six different ways. When the three independent factors with their six possible variations are considered as a whole, we realize that there are 216 independent combinations possible. But the 216 independent combinations do not give 216 different final scores. They give but 16 different scores (from 3 to 18). Nor do the 216 combinations give an equal number of each of the 16 different scores. They give varying numbers of the 16 different scores—only one 3, three 4s, six 5s, etc., as in the table above.

Now in a similar way we may think of the characters of different individuals as the final scores resulting from the interaction of many independent factors, each of which may vary independently in many ways. Instead of there being but three factors with six variations each, which combined give us our human individualities, there are undoubtedly many more than three factors and these factors have many more than six variations. Nevertheless the final outcome is very similar

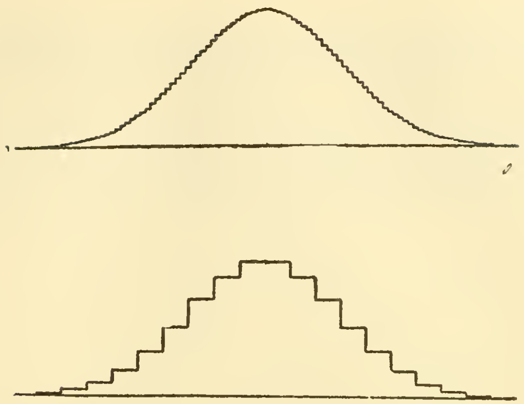


Plate XV. The normal curve or surface of distribution. The two curves differ only in that a coarse unit of measurement was employed in the second case whereas a fine unit was employed in the first case;--i.e., inches vs. eighths of an inch. (From E. L. Thorndike, Educational Psychology, Vol. 111., p. 334.

to what we obtain by throwing dice. We find that most of the individuals, just like most of the throws, give us individualities that resemble each other very much, just as the throws of 8, 9, 10, 11, 12, and 13 are very much alike. We find also that occasionally we get very striking personalities, just as very occasionally we get throws of 3 or 4 or 17 or 18. They are striking because they differ so from what we ordinarily have.

In Plate XV are given two different methods of drawing the typical surface of distribution. In the lower of these two surfaces there was used a very coarse unit of measurement, e. g., inches in measuring height, and in the upper surface there was used a very much finer unit of measurement, e. g., eighths of an inch. We can imagine a surface drawn on the basis of a still finer unit of measurement. In this case the jogs in the line would be very, very small, so that for all practical purposes the line would be a smooth curve and not a jagged line. Such a curve is called the *normal curve of distribution*. In terms of geometry the normal curve of distribution is the limit approached by most surfaces of distribution which are obtained in biological studies.

THE DISTRIBUTION OF INDIVIDUAL DIFFERENCES.

An Ideal Distribution. When we come to study human beings we find that they fit into our normal surface wonderfully well. In fact, the

conception has been derived from our study of individual differences. In Plate XVI is shown a normal curve of distribution picturing the different types of individuals according to general intelligence. In the middle are the great bulk (50%) of human beings—average human beings. As we proceed to the left, we have individuals slightly below the average; "dull" persons; morons with intelligence approximately equal to children from 8.0 to 10.0 years;* and then

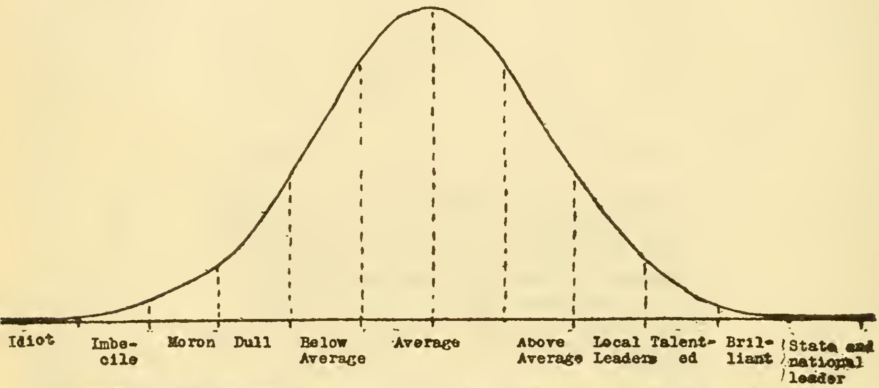


Plate XVI. A normal surface of distribution divided up into twelve groups showing eleven degrees of general intelligence (the middle two groups are together considered as typical of average intelligence).
Note: In this diagram the surface is so divided up that the intervals along the base line are equal. In other words, the difference in general intelligence between any two groups are equal. The areas so marked off are not equal. 50% of the entire 100,000,000 population of the United States would be placed in the two middle areas designated "average." On the other hand about 2% of the population would be included in the last three groups at the left.

imbeciles with intelligence of from 2.0 to 8.0 years; and idiots with intelligence of from 0.0 to 2.0 years. The remaining 0.001% of the inferior population can possibly be thought of as being too inferior to live and so constitute a fraction of those who are born dead. In the same way we may divide up our superior individuals proceeding from the middle group out toward the right. Apparently we have no terms to cover these superior individuals so that the expressions used here have no standard meaning. To the right of the group entitled "National Leaders," comprising 29,000 in a population of 100,000,000 are still 1,000 individuals not to be overlooked. They comprise our most valuable men, our geniuses, etc.

Professor Cattell** in his study of the thousand most eminent men of

*There is a great deal of controversy today as to what should be the proper mental-age limit of morons. Some writers place it as high as 12 years. Experience based upon testing men in the army makes 10 years a satisfactory figure.

**J. McK. Cattell, A Statistical Study of Eminent Men, Popular Science Monthly, Feb., 1903.

history, studied a group even more eminent than these since his thousand was not taken from a population of 100,000,000 but from the population of the known civilized world. They would be located on this diagram several groups to the right of the group here entitled "National Leaders." According to Cattell the ten most eminent men of all history are the following in the order of their prominence:— Napoleon, Shakespeare, Mohammed, Voltaire, Bacon, Aristotle, Gœthe, Julius Cæsar, Luther, and Plato.

ACTUAL DISTRIBUTIONS OF INDIVIDUAL DIFFERENCES.

In Lesson 22 our attention was called to the fact that the averages of the eight grades of a school may be equal or superior to the norms for those grades, and yet many children in each grade may be in a very bad way educationally. The specific case was mentioned of testing a school with the Kansas Silent Reading Test and the individual scores for all the children were presented in Table VI. These scores are again given in Plate XVIII, where they are displayed as surfaces of distribution. Because of the small number of children in any class these surfaces only remotely approximate the form of the surface of distribution which would be obtained if there had been 100 or 200 children in each grade. When the scores from all the children in Grades IV to VIII are combined, as they are in the lower part of Plate XVIII, a surface of distribution much more similar to the typical form is obtained. If the scores from the children in Grades I to III had been included the surface of distribution would be still more similar to the usually obtained form. Nevertheless the form obtained here is typical of the form which results from a study of individual differences in nearly all traits, both mental and physical.

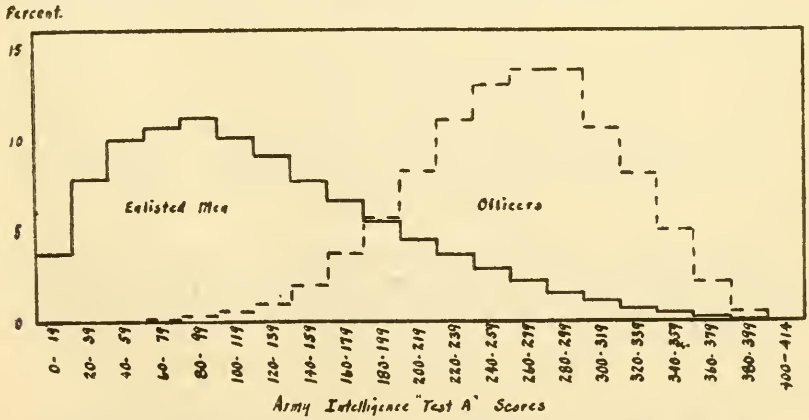


Plate XVII. Showing the distribution of scores obtained by enlisted men and officers in psychological intelligence test (Test A). Based on scores of 128,747 "literate"men and 8096 white officers. Undoubtedly many enlisted men too illiterate to take the test were included here.

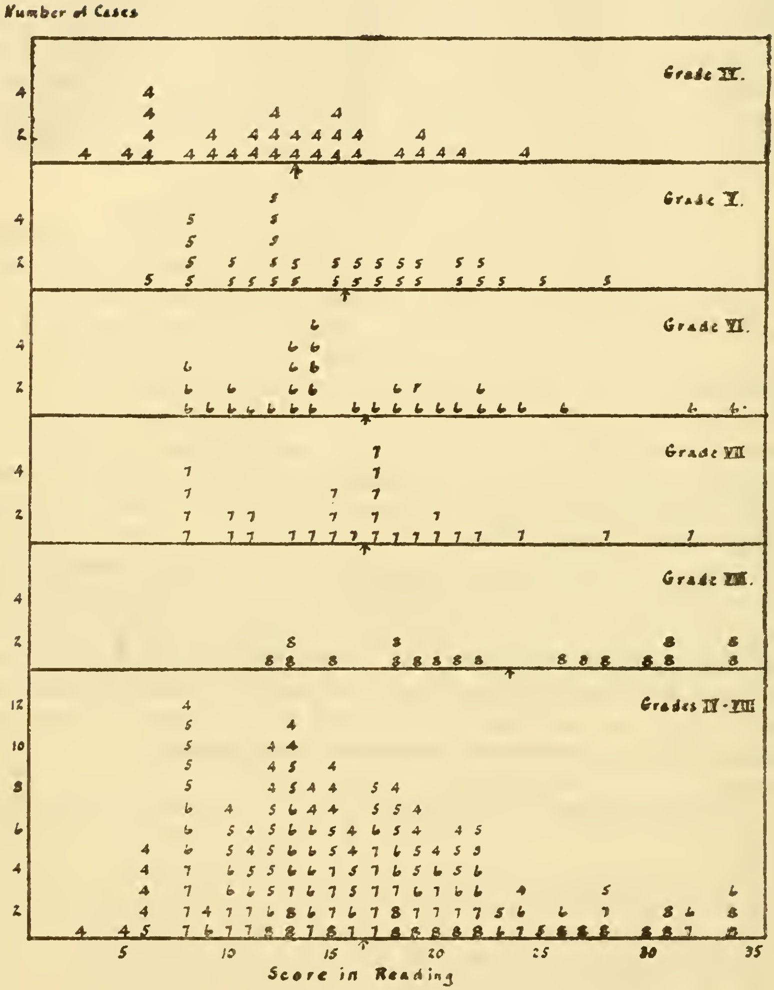


Plate XVIII. Showing the Distribution of Children in Grades IV to VIII, based on the Kansas Silent Reading Test. (See Table VI for individual scores.) (Averages of each grade indicated by the arrows.)

During the war a psychological "general intelligence" test was given to hundreds of thousands of the enlisted men and to many of the officers. Distributions of the scores obtained are shown in Plate XVII. They show that the officers were as a class superior to the enlisted men in intelligence. This fact may be expressed also as follows:

2.4% of the enlisted men were superior to 75% of the officers
6.4% of the enlisted men were superior to 50% of the officers
12.2% of the enlisted men were superior to 25% of the officers

Intelligence is not the only qualification needed by officers. Some of those with low intelligence scores were superior in leadership and experience. In the same way some of the enlisted men who were very superior in intelligence had very poor physique and appearance or were lacking in education or leadership, etc. From the standpoint of the psychologists and personnel officers the problem of selection of men for officers' training camps was to find the superior enlisted men—superior both in intelligence and other necessary qualifications.

The sharp drop at the extreme left of the enlisted men's distribution curve proves conclusively that many enlisted men were not measured here who belonged to the group of enlisted men. This was true. Twenty-five per cent. of men were eliminated by the draft boards as below standard physically, mentally or morally. And the worst illiterates were not given the test. Illiterates and those making a poor score in this test were given a test not involving reading.

FUNDAMENTAL CAUSES OF INDIVIDUAL DIFFERENCES.

Individual differences are to be thought of as the resultant of many more or less independent factors, each of which vary considerably. These factors may be grouped under the three headings—environment, heredity and training. The different acts now being performed by human beings in this country this moment are due to the situations confronting them, their innate make-up, and their previous experiences. In the case of heredity, we may look upon a human being as made up of many factors handed down to him from his parents thru the two germ cells. These factors are more or less independent. According to the combination which results from all these factors we have any particular human being. As illustrated by the experiment in throwing dice, altho there may be many combinations of factors with their individual variations there results (1) a much smaller number of distinct individualities and (2) the great majority of such individualities are much alike with only relatively few cases of marked variation from the average.

One factor which causes individual differences. At the present time science has ascertained in only a few cases what the factors are which

affect human beings so as to make them different. And even there this has been done only to a limited degree. One example may be mentioned simply to make this matter clearer. In the throat or neck are some small glands known as the *thyroid* glands. They secrete into the blood a substance which is "characterized by containing a large amount of iodin (9.3% of the dry weight)." This chemical, apparently, exercises in the tissues "a regulating action of an important or indeed essential character." Removal or atrophy of the thyroids results in a condition of chronic malnutrition; "in the young it is responsible for arrested growth and deficient development designated as cretinism, and in the adult the same cause gives rise to the peculiar disease of myxedema, characterized by distressing mental deterioration, an edematous (dropsy of the subcutaneous cellular tissue) condition of the skin, loss of hair, etc." On the other hand, enlargement of the thyroid glands "forms an essential factor of the disease exophthalmic goitre." "The salient feature of exophthalmic goitre is a lowered threshold to all stimuli." "The organism responds at such times to the prick of a pin, a hint of danger, or the slightest infection, by a transformation of energy many times greater than would follow the same stimulation in the normal organism." Patients suffering from cretinism are now fed this iodin chemical, whereas patients suffering from exophthalmic goitre are

TABLE VIII. SHOWING THE PERCENTAGE OF 4th AND 8th GRADE CHILDREN WHO (a) ATTEMPTED AND (b) SOLVED FROM 0 TO 20 PROBLEMS

	Per cent. of Pupils who *attempted* to do a Given Number of Problems.		Per cent. of Pupils who *Solved Correctly* a Given Number of Problems.	
	4th GRADE	8th GRADE	4th Grade	8th Grade
20 Probs.	0%	5%	0%	2%
19 "	0	2	0	1
18 "	0	2	0	1
17 "	0	3	0	1
16 "	1	4	0	2
15 "	1	6	0	2
14 "	1	7	0	3
13 "	1	8	1	4
12 "	1	9	1	5
11 "	2	11	1	7
10 "	4	11	1	8
9 "	5	10	2	8
8 "	12	10	3	10
7 "	14	6	6	10
6 "	21	4	9	9
5 "	14	1	12	9
4 "	13	1	14	7
3 "	6	0	14	6
2 "	3	0	13	3
1 "	1	0	13	1
0 "	0	0	10	1
Aver.	6.44	11.65	3.81	8.41

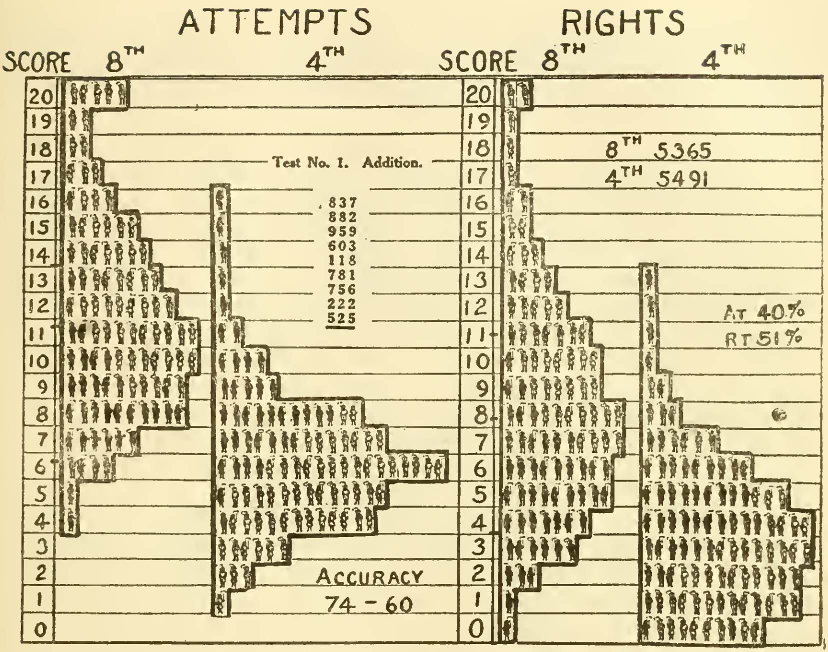


Plate XIX. Showing the percentage of 4th and 8th grade children who (a) attempted and (b) got right from 0 to 20 problems in eight minutes. (Each figure represents one child in a class of one hundred. The figures in black represent children in the 4th grade who could be interchanged with corresponding children in the 8th grade without affecting the averages or A.D.s of either grade. From S. A. Courtis, Educational Diagnosis, Second Indiana Educational Conference, p 154.)

operated on so as to reduce the amount of this chemical given off by the thyroid glands. We see here a single factor in the entire organism —the production of an iodine chemical—which when only slightly produced results in cretinism (deficient physical and mental development), when normally produced results in normal behavior, and when excessively produced results in goitre accompanied by a chronic state of great excitability.*

THE OVERLAPPING OF DISTRIBUTIONS OF ABILITY IN DIFFERENT SCHOOL GRADES.

The scores of children in the Kansas Silent Reading Test for the various school grades overlap enormously (See Plate XVIII). Because

* Quotations are from W. H. Howell, Physiology, 1907, pp. 794-797 and G. W. Crile, Man—An Adaptive Mechanism, 1916, pp. 140-143 and 192-197.

it is one of the most important conceptions in educational theory today it will repay us to consider still another example of it here. In Table VIII are given the records of 4th and 8th Grade children in column addition.*

The type of example used in the test is illustrated in Plate XIX. (Examples of this sort make up the Addition Problems in the Courtis Arithmetic Tests). Courtis measures the *speed* of work by recording the number of problems "attempted" and the *accuracy* of the work by recording the number of problems which were "right" or correct. The four columns show what per cent. of the two grades "attempted" or got "right" any specific number of problems ranging from 20 to 0. For example, the table shows that 0% of the 4th Grade attempted 20 problems while 5% of the 8th Grade attempted that number, and it shows that naturally 0% of the 4th Grade got 20 problems right, while 2% of the 8th Grade did solve that number correctly. It shows further that 1% of the 4th Grade attempted 12 problems as against 9% of the 8th Grade, and that 1% of the 4th Grade got 12 problems right, as against 5% in the 8th Grade. If we want to know just how many children attempted or solved correctly 12 or more problems in the two grades we must add up all the percents. in the table for 12 problems and better. This gives us the following: 5% of the 4th Grade attempted 12 or more problems as against 46% of the 8th Grade and 2% of the 4th Grade got right 12 or more problems as against 21% of the 8th Grade. All of this is shown diagrammatically in Plate XIX.

The averages of the 4th and 8th Grades are given at the bottom of the table. The 8th Grade has done just about twice as well as the 4th Grade on the basis of these figures. In terms of such figures one would expect that *all* 8th Grade children would be superior to all 4th Grade children for the former averages 8.4 problems correct to 3.8 problems for the latter. But a study of the table and particularly the plate shows that this is false. Fifty-one of the children in the 8th Grade could be put in the 4th Grade and a corresponding number in the 4th Grade be put in the 8th Grade and the averages of the two grades for accuracy would not be affected at all. When we give our 8th Grade children a diploma, graduating them into the High School, we feel that the diploma means that they are up to 8th Grade standards and far superior to 7th, or 6th, or 5th, or certainly 4th Grade standards. But apparently many in the class are not. For here in this perfectly typical illustration based on about 11,000 children, 38 in every hundred 8th Grade children are no different from 38 other children in

*S. A. Courtis, **Educational Diagnosis**, Second Indiana Educational Conference, 1915, p. 154.

the 4th Grade as regards their speed of adding and 51 in every hundred 8th Grade children are no different from 51 other 4th Grade children as regards their ability to add correctly columns of figures.

This comparison between the two grades may be made in another way. The average number of problems solved correctly in the 4th Grade is 3.8. There are 11 children in the 8th Grade inferior to the average of 4th Grade children. And in like manner there are 6 children in the 4th Grade who are clearly superior to the 8th Grade average of 8.4 problems. Averages in this case clearly mean very little. The differences among the children themselves in either class are far more significant than the two class averages based on the individual records.

In a similar way the A. D. may be determined for the data in Table VIII concerning the ability of children in the 4th and 8th Grades to add columns of figures. We then have:—

Average number of problems attempted in 4th Grade	6.44,	A. D. 1.94
Average number of problems attempted in 8th Grade	11.65,	A. D. 2.69
Average number of problems correctly solved in 4th Grade	3.81,	A. D. 2.19
Average number of problems correctly solved in 8th Grade	8.41,	A. D. 3.09

As pointed out in Lesson 22 the size of these A. D.'s immediately warns us against supposing that all the children are equal to the average for their grade. They also confirm again the point made in Lesson 24 that the greater the training the more the individuals are different. Inspection of the surfaces of distribution in Plate XIX, as well as the size of these A. D.'s shows that the members of the 8th Grade differ more among themselves than do the members of the 4th Grade. This fact would be all the more clearly shown if the children who have dropped out of school between the 4th and 8th Grades, were present in this 8th Grade. For most of them would appear at the lower end of the surface of distribution.

This matter of how children differ among themselves is a very important problem affecting our whole educational system in a very profound way. When we realize that 51 of 8th Grade children add columns of figures no more accurately than a corresponding number of 4th Grade children we feel that something must be wrong with our school system. All of our methods of study, all of our methods for supervision, and all of our administration schemes should be subjected to careful scrutiny in order to see if any of them are the cause for this astounding comparison. Possibly, radical changes might produce a more uniform proficiency in the grades. Possibly the graded system itself is at fault. Possibly the differences discussed here are inherent in children themselves, so that very little or nothing can be done to

rectify the matter. If that is the case, then, changes possibly should be made so that 8th Grade diplomas might have a more definite meaning than they now apparently have.

LESSON 27. HOW SHOULD STUDENTS BE GRADED?

One of the most perplexing problems in education today is that of grading students. Until very recently the subject was ignored, for it was taken for granted that if a person was capable of teaching his class he was capable of grading the students in that class. Even today, the vast majority of teachers consider it their inalienable right to grade as they please and strenuously resent any interference with their methods. Recent studies made on this subject show, however, that teachers differ very widely in the way they grade their students. In fact, the variation is so great that it is perfectly apparent that all cannot be grading their students fairly. And when "honors" are based on the grades of different instructors the injustice of the present system is clearly apparent. A friend of the writer deliberately restricted his work as far as possible to the three departments of Latin, German, and History in a great university, because he realized that it was easy to make high grades there and he was determined to win Phi Beta Kappa. These three departments granted "A's" to 30% of their students, while many other departments granted "A's" to less than 5% of their students. He made his Phi Beta Kappa key but at the expense of a broad well-rounded college training. If he had taken courses from many departments he would have stood certainly less than half the chance of getting high grades and probably not more than one-third the chance.

Below are given (See Table IX) the grades which an instructor awarded a class in history. They are the grades from three examinations, and the final grade for the semester is to be made up from them, each of the three to count one-third of the final grade. (The grades were obtained by the instructor assigning definite values to each question or part of a question, scoring the student in terms of each question, and finally totalling all these separate scores. The grades given here have been modified somewhat by the writer but they approximate in a general way the grades actually given by this instructor.)

Plot surfaces of distribution for the three sets of grades listed below.

TABLE IX. THE GRADES GIVEN BY AN INSTRUCTOR IN THREE EXAMINATIONS. WHAT SHOULD BE THE FINAL GRADE OF EACH STUDENT?

Students	First Exam.	Sec. Exam.	Third Exam.	Final Grade
1	60	100	70	
2	55	90	55	
3	50	80	80	
4	45	95	55	
5	45	85	70	
6	40	95	50	
7	40	80	50	
8	35	70	65	
9	35	85	45	
10	30	75	60	
11	30	80	50	
12	30	90	75	
13	25	95	30	
14	25	90	60	
15	20	90	55	
16	20	85	55	
17	20	80	35	
18	15	100	50	
19	15	65	40	
20	10	80	45	
21	10	85	35	
22	5	85	45	
23	5	60	30	
24	0	75	25	

Answer the following questions:—

1. Who is responsible for the low grades in the first examination and the high grades in the second examination? Do the grades mean that the students loafed before the first examination and studied hard before the second? Or do they mean that the first examination was too hard or too long and the second too easy or too short? Or do they mean that the course of study was poorly organized at the beginning and the teaching was poor at the start and after the poor showing in the first examination the teacher "woke up" and "got busy" and did good teaching?

Who, then, is primarily responsible for the grades in the first examination ranging from 60 to 0 and in the second examination from 100 to 60?

2. Which grade represents the greater ability, 60 given in the first examination or 80 given in the second? 60 is 20% inferior to 80, of course. But, on the other hand, only one student received 60 in the first examination and none received a higher rating, whereas in the second examination 5 students received 80 and 14 more received higher grades than 80.

3. If we arrange the students by order of merit according to their grades in the three examinations, we find that the

best student got 60, 100 and 80, respectively,
the 12th student got 30, 85 and 50, respectively, and
the poorest student got 0, 60 and 25, respectively.

Are 60, 100 and 80 equal then? or 30, 85 and 50? or 0, 60 and 25?

4. In grading examination papers should we grade in terms of the "ideal" paper, the best paper, the paper of an average student, or the poorest paper? With which one of these standards is the teacher most likely to be familiar? Which one is most likely to fluctuate from year to year?

5. What final grades would you give these 24 students on the basis of the three examinations? Plot the surface of distribution for the grades you assign.

6. Are your final grades fair to the students? to the instructor? to students in other classes in the institution? to other instructors? to the institution as a whole? Explain.

Hand in your report at the next class-hour.

LESSON 28 —METHODS OF GRADING STUDENTS*

The matter of grading students in a class is a subject that is intimately connected with the subject of individual differences. It is introduced here as an illustration of how this subject is related in still another way to educational theory and practice.

SYSTEMS OF MARKING STUDENTS.

Grading on Percentage Basis with Prescribed Passing Mark. One of the two most universally used systems of grading students is to give students grades ranging from 0 to 100, with some grade as 50, or 60, or 75, or even 80, as a passing mark.

The theory underlying the granting of percentages is that the student is *graded in terms of absolute proficiency.* If he gets 90 in an examination in arithmetic or spelling, he has done 90% of the examination correctly. The system works fairly well here. But it falls down completely in such subjects as English Composition, or history or geography, etc. For who knows what is absolute proficiency in composition work for 5th grade children? How does such a standard differ from the 4th grade, or from the 6th grade? Actually in ordinary practise the grades represent at best only a certain percentage of what the teacher considers the class can do. It is based on two very variable things—the teacher's estimate of what the class can do, and second—the class itself. If the class is better than usual, the teacher's grades stand for better work than usual; if the class is poorer than usual, the teacher's grades represent poorer work than usual. Despite the best efforts of any teacher his grades are not standardized on the basis of a fixed absolute standard but vary with the calibre of his pupils. It is impossible under such conditions to ever expect that a "85" will represent a definite standard of work in a particular course. The 85 will vary from year to year with the same teacher, and it will vary with every two teachers, depending on those teachers' estimates of what a class can do. (All of these statements have been substantiated in every investigation on this subject and are no longer open to argument.)

Grading on Basis of Five Groups. The other most universally used system of grading students is to give the students grades in terms of about five letters or numbers, such as A, B, C, D, and F; or E, S, M,

*CLASS-HOUR	IN CLASS	WRITE UP	READ
28	Discuss, Lesson 27		Lesson 28
29	Experiment, Les. 29	Lesson 29	

I, and F; or again 1, 2, 3, 4, and 5. The A, E, or 1 is given to the best students; the B, S, or 2, to the next best group; etc. The F or 5 is considered as failure. Sometimes the fourth grade, D, I, or 4 is "not passing" and sometimes it is considered as "conditioned" requiring another examination. At still other institutions D is a passing grade but entitles the student to but 80% credit, so that in a 5-hour course the student with a D will receive but 4 hours credit.

It is because of insurmountable difficulties pointed out above in connection with the percentage system of marking that this system of grading students with five letters has arisen. The whole scheme of grading students on the basis of an absolute standard of perfection is thrown away, or almost thrown away* The teacher then roughly divides the class into five groups, the excellent students, the good, the fair, the inferior, and the failures. More or less of the old scheme survives in the case of deciding just what will constitute a passing standard as distinguished from a failure. The essential thing, however, is the division of the class into five groups in terms of their general ability and performance in the particular class.

Anyone familiar with the laws underlying individual differences immediately realizes that these five groups should not contain an equal number of students;—that the largest number of students should be in the middle group, and that relatively few should be in the two extreme groups, the excellent students and the failures. But the study of how teachers grade students shows clearly that teachers differ enormously as to how they distribute their grades under this scheme. In Table X is shown the distrbution of grades in seven courses in the University of Missouri prior to 1908. It is clear from this table, and it represents conditions in every institution of that time and most institutions today, that a student could quite easily win "honors," or a scholarship, or make Phi Beta Kappa by electing Philosophy, Economics, etc., but would have an extremely small chance of obtaining these honors if he grouped in Chemistry. Yet an "A" counted equally toward these honors whether obtained in Philosophy or Chemistry III. In the same way a poor student would have little trouble in passing Philosophy but would stand a good chance of being "flunked" in English II or Chemistry III. The problem educators are now facing in regard to grading students is how to make an "A" or "F" mean the same thing whether given by Prof. Smith or Prof. Brown, whether given in Philosophy or Chemistry, whether given in 1915 or 1917.

*Of course, in those cases where a teacher marks a student by these five letters but always translates the letter into a numerical figure, so that A equals 100 to 95; B, 95 to 85; etc.; he is practically following the first scheme and not the second. When the second scheme is used properly there are no numerical values attached to the letters.

TABLE X. SHOWING THE RELATIVE FREQUENCY OF FOUR GRADES A, B. C, AND F, AS FOUND BY MAX MEYER IN THE UNIVERSITY OF MISSOURI, IN 1908.

(Table based on Max Meyer, *"The Grading of Students," Science, August* 21, 1908, p. 3.)

Course	Distribution of Grades				Total No. of Students Considered
	A	B	C	F	
Philosophy	55	33	10	2	623
Economics	39	37	19	5	161
German II	26	38	25	11	941
Education	18	38	35	9	266
Mechanics	18	26	42	14	495
English II	9	28	35	28	1098
Chemistry III	1	11	60	28	1903

An important step toward obtaining equitable grading has been to apply the conception of our normal surface of distribution to the problem. Any group of students (barring exceptional cases considered below) will divide themselves up into inferior, average, and superior students and these three groups will approximate 25%, 50% and 25% in size, respectively. They will do so if the method of grading them is fair. If, however, the examination is too easy or too difficult there will appear not a normal distribution but one in which there are too many superior or too many inferior students, respectively. If in two classes of 100 students, Prof. Smith and Prof. Brown require a *fair* amount of work, then 25% of the students will do superior work, 50% average work and 25% inferior work. If Prof. Smith requires too much and Prof. Brown too little, then it may appear that the former has 40% inferior and 10% superior students whereas the latter has 10% inferior and 40% superior students. If we require each professor to grade 25% of his students superior, 50% average, and 25% inferior, then we recognize (1) that one class of students taken as a whole is about equal to any other class and (2) that students are graded in terms of what an average student will do and not in terms of a variable standard of what is required by different instructors. In such a case we know that a "superior" student for Prof. Smith has actually done better work than ¾ of the students in his class and that a "superior" student for Prof. Brown has likewise excelled ¾ of his class. *A given grade is not then a grade in terms of any absolute standard of perfection but is a grade in terms of what average students can do.*

With such a requirement the irregular grading shown in Table X was eliminated to a large extent at the University of Missouri. The average of all the grades for the undergraduate courses became in 1911, 23.7% superior, 49.9% average,

and 26.4% inferior. Nineteen of the instructors distributed their grades as shown in Table XI. Comparison of the individual instructor's gradings in this table with those in Table X shows an enormous improvement in the way of uniform grading on the part of the faculty. An "E" now means nearly the same high grade of scholarship whether given by one instructor or another. The gradings in Table XI are, however, still too irregular as respecting Grades "I" and "F" to be entirely satisfactory.

The Missouri System of Grading. As can be seen from Table XI, the Missouri system of grading students provides first of all for the students being divided into three groups,—superior, average, and inferior,—so that the first group comprises the best 25% of the students, the second group the middle 50%, and the third the remainder. The superior and inferior are further divided so that in effect there are five grades of E (excellent), S (superior), M (medium), I (inferior), and F (failure). As illustrated in Plate XX the surface of

TABLE XI. SHOWING THE RELATIVE FREQUENCY OF THE FIVE GRADES E, S, M, I, AND F, AS USED BY VARIOUS INSTRUCTORS IN THE UNIVERSITY OF MISSOURI IN 1911.

(Based on the *"Report of the Committee on Statistics on the Grading of the Semester,"* Closing Feb., 1911.)

Instructors	% E	% S	% M	% I	% F
A	7	29	51	8	5
B	5	23	52	15	5
C	3	21	51	21	4
D	7	21	56	8	8
E	6	15	60	13	6
F	1	22	55	17	5
G	2	17	64	11	6
H	3	21	52	18	6
I	3	24	46	21	6
J	3	20	51	20	6
K	3	20	53	16	8
L	3	23	47	17	10
M	2	19	55	14	10
N	4	19	45	23	9
O	5	20	43	21	11
P	7	21	47	9	16
Q	3	13	52	19	13
R	5	11	43	29	12
S	3	15	47	20	15
Average	3.9	19.7	51.0	16.8	8.5
	23.6		51.0	25.3	

distribution is so divided that the difference in ability represented by Grades E and S is equal to the difference between S and M, or

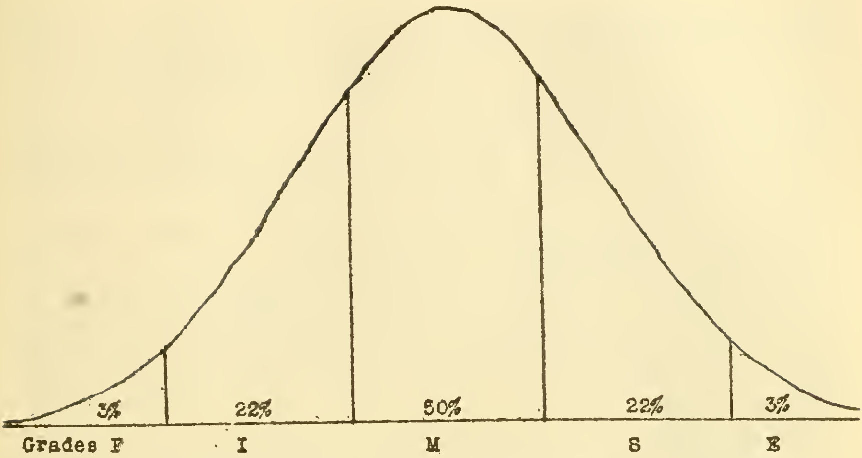


Plate XX. A normal surface of distribution divided up into five groups showing five grades of scholarship. At the University of Missouri these five grades are called F (failure), I (inferior), M (medium), S (superior), and E (excellent). At Peabody College the grades are called F (failure), D (inferior), C (average), B (superior), and A (excellent.)

M and I, or I and F. The standard which all instructors are expected to reach in their grading is then that 50% of the students shall receive an M, 22% an S, 22% an I, 3% an E, and 3% an F.

One objection to this scheme will immediately occur to some readers. Maybe half the class has actually failed and you have given most of them a C or D. Will that method of marking be fair? Yes, certainly; for if half the class fails, who is to blame? Undoubtedly, in practically every case, no one but the teacher. The examination was too difficult, or too long, or because of poor discipline the students had not studied. This system throws the blame for poor work in the class on the person who deserves the blame—the teacher. Of course, sometimes a group of students will not work, then the only final resort is to "flunk" them. But such cases are rare as compared with those where the trouble lies in the main with the instructor.

Here are the faculty rules at George Peabody College for Teachers on this subject. They make plain that the above system applies directly to large classes and only indirectly to small classes, and possibly not at all to exceptional classes, such as in graduate courses.

"It is fair to assume that the average student in any undergraduate course is equal in ability to the average student in any other undergraduate course. Consequently it is fair to expect that all members of the faculty will in the long run

(when they have marked 500 students, say) give approximately the same per cent. of students each of the five grades.

"It is also fair to assume that the calibre of classes does vary, and that this is particularly true in the case of very small classes. Consequently it is fair to expect that the members of the faculty will vary considerably in the way they mark the members of particular classes.

"We expect then in the long run that the members of the faculty will all use the same standards. We also expect, on the other hand, that there will be noticeable variation in the way individual classes will be marked. In the light of these assumptions, the following rules are laid down:

"I. The quality of the student's work in a course shall be reported to the registrar by use of the following grades: A, B, C, D, and F.

"2. The grade of "C" is designed to represent the performance of the middle 50% of the class. The grades of "B," and "D" represent work that is superior and inferior, respectively, to that of the middle group. The grade of "A" is reserved for markedly superior work, while the grade of "F" is designed for those who have failed and shall receive no credit for their work. Students receiving the grade of "D" will receive but 80% of the full credit attached to the course, i. e., in a five-hour course such a student will receive but four hours credit.

"3. It is recognized that the more advanced the student the more selected is the class with which he will be grouped and the system of marking will vary proportionately.

"4. Experience has shown that in the long run the instructor will give approximately 3% of his students an "A," 22% of his students a "B," 50% a "C," 22% a "D," and 3% an "F"."

Such a uniformity of grades from the members of a faculty is highly desirable and is to be expected so long as it can be assumed that the calibre of students in one class is equivalent to those in another class. If an instructor gives proportionately more low or high grades in his classes than this ideal, he declares in so doing that his students are poorer or better than the students in other classes. This is, of course, in many cases an actual fact, and when so, an instructor should mark accordingly. But in the ordinary course of events one class is pretty nearly equivalent to another class as far as ability of the students composing it is concerned.

Varying the Amount of Credit with the Grade Given. The University of Missouri further provides that students shall obtain varying amounts of credit for their work according as they obtain high or low grades. At the present time in a one hour course, a student obtaining an E earns 1.15 hours credit, a student obtaining an S earns 1.10 hours credit, a student obtaining an M earns 1.00 hour credit, a student obtaining an I earns 0.85 hour credit, and a student obtaining an F earns 0 credit. Prof. Max Meyer, who has been responsible for the adoption of the Missouri scheme of grading, is now advocating that the grades shall carry these amounts of credit:—E (1.2 hrs. credit), S (1.1 hrs. credit), M (1.0 hr. credit), I (0.9 hr. credit), and P (poor) (0.8 hr. credit). A student "who ought to repeat the course

before his attainments are recognized, and who therefore is marked F by his teachers, would receive no credit toward graduation.*

PRESENT TENDENCIES IN GRADING.

Among colleges and universities the tendency is away from the percentage system to the group system and to a limited extent toward the Missouri system, which has been adopted more or less entirely in a number of institutions.

Among secondary schools, today, 30% employ percentage systems and 65% the group system. Of those using the group system, 44% have three grades above passing, 52% have four grades, and 4% have five grades. The National Conference Committee on Standards of Colleges and Secondary Colleges recommends that, "if a group system is used, the letters A, B, C, or A, B, C, D be employed to indicate passing grades, and that E or F, or both E and F, be reserved for failure. The committee calls attention to the fact that the majority of colleges use four groups above passing, and that the tendency in schools appears to be in that direction.

"The committee recommends that schools using a percentage system follow what appears to be the most common practice, of using 60 as the passing grade.**

So in school grades any student must be compared with his class and with the average of the class, not with the best one in the class, and fortunately, as investigations have shown that the average performance in one class is approximately the same as that in other classes, we do have quite a stable standard from which to measure.

DISCUSSION OF THE PROBLEM ASSIGNED IN LESSON 27.

With these general considerations before us let us turn now and consider the problem which was assigned in Lesson 27.

The Surfaces of Distribution; What They Show. The grades from the three examinations given in Lesson 27 are plotted in surfaces of distribution in Plate XXI. The three surfaces approximate the normal surface of distribution. The first one is long drawn out: the effect obtained when the examination is too difficult. The low grades show the same fact. The second distribution is skewed—most of the grades are bunched at the upper end. This is characteristic of too easy an examination or one where nearly all could answer the questions in the alloted time. If the time had been cut in half the distribution would have resembled that of the third examination.

If we followed the old scheme of marking where, say, 60 was the passing mark, we would, in the first examination, if we were true to

*Max Meyer, The Administration of College Grades, School and Society, Oct, 23, 1915.
**Report in School and Society, March 1, 1918, by Headmaster Ferrand.

our standards and had the requisite courage, fail all but one in the class. In the second examination we would pass every one, and in the third we would fail 17, or 71% of the class. Averaging the three sets of grades we obtain the results given at the bottom of Plate XXI. These grades would necessitate our failing 14 members of the class, or 58%. If the passing grade were 75 but one of the class would pass. If it were 50 then 7 would fail, or 29%.

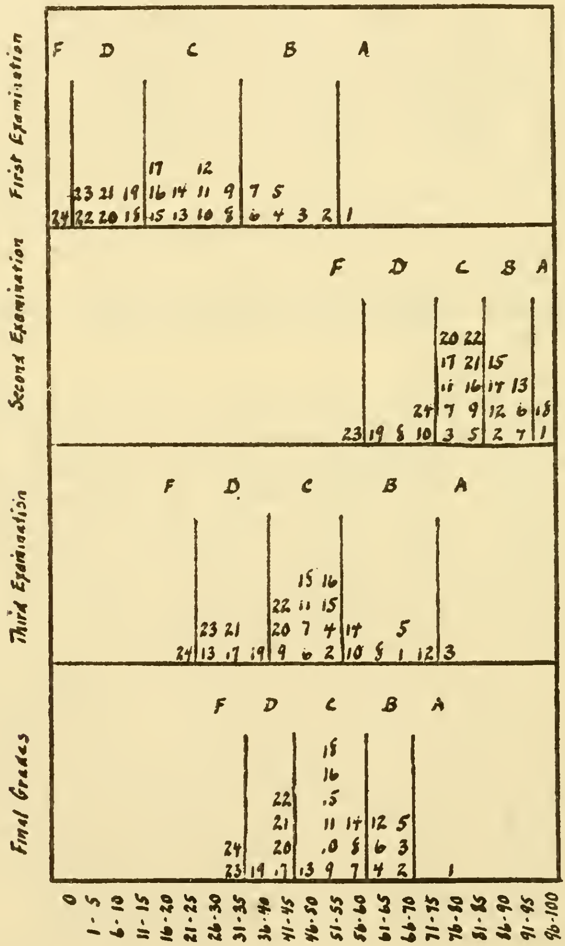


Plate XXI. The examination grades given in Table IX and the computed final grades plotted in surfaces of distribution, together with their conversion into Grades A, B, C, D and F.

This example is an extreme one, but is based on an actual case. It is, however, useful here as it points out in an exaggerated form the real situation that confronts the majority of instructors in their marking of students' papers. The grades a class actually receives, considering the class as a whole, are dependent on the instructor and him alone. If the examination is difficult the class as a whole gets low grades, if the examination is easy the class as a whole gets high grades. Instructors who mark low are generally instructors who require much from their students, while instructors who mark high do not require enough. Of course, there are many exceptions to this rule. To set up a standard such as 60 or 75 as a passing mark is to postulate that the instructor is omnipotent, that he knows exactly how easy or difficult to make an examination. Such an assumption is preposterous.

The only method now known to education whereby the standard of a class may be determined is to assume that the average student in one class is equal to the average student in another. This assumption is correct remarkably often, as determined by actual investigation. When this is done, the middle half of the class, regardless of whether they obtain 30, 85, or 50, are graded C. The upper fourth are graded A or B, and the lower fourth, D or F. Just how that is done is indicated in Plate XXI. Theoretically 3% should receive an A and an equal number an F. In actual practice, an instructor should feel free to give no A or F, or several, depending on the circumstances of the case. On the basis of Plate XXI,

1 student would receive an A, or 4%
6 students would receive a B, or 25%
10 students would receive a C, or 42%
5 students would receive a D, or 21%
2 students would receive an F, or 8%

The A and F grades must depend on circumstances.

In this particular case Student 1 is so far ahead that he alone would be given an "A" unless the work of the class, including 1's work, was not very good. In the same way no grade of "F" might be given if the work of 23 and 24 was acceptable; or if the work was poor 19 might also be given an "F." But in the long run, the instructor should give grades approximately as follows:—A-3%, B-22%, C-50%. D-22% and F-3%.

How to Grade Papers. There are undoubtedly many good methods of grading a student's paper. Circumstances will determine whether one will read the whole paper thru and grade it as a whole, or whether one will grade each part and then total the parts. The two give

about the same result. *Regardless of how the papers are individually scored, when that operation is done, one should convert the temporary grades into the grades A, B, C, D, and F. Divide the class into four fairly equal groups. Grade the first group A and B, the two middle groups C, and the fourth group D and F. If there are any exceptionally good or bad papers grade them A, or F, accordingly.*

Some instructors find the easiest method is to read the paper thru, judge its total value and place it in one of seven piles according to its merit. When all are finished the piles are readjusted if the first two do not contain approximately 25%, the next three 50% and the last two 25%. They are then graded, respectively, A. B. C+, C, C—, D and F. Practically nothing is gained by the subdivision of Group C into three sub-divisions, except to make the instructor feel he is doing a more accurate job.

How to Record Grades. The practical problem arises, how shall I keep my record book? In Table XII are presented three methods of keeping a class-record. The first method consists in grading in

TABLE XII. EXAMINATION GRADES, GIVEN IN TABLE IX, AVERAGED BY THREE DIFFERENT METHODS

Student	FIRST METHOD					SECOND METHOD				THIRD METHOD				
	1st	2nd	3rd	Av	By letters	1st	2nd	3rd	Av	1st	2nd	3rd	Av	By letters
1	60	100	70	77	A	A	A	B	A	4	4	3	3.7	A
2	55	90	55	67	B	B	B	C	B	3	3	2	2.7	B
3	50	80	80	70	B	B	C	A	B	3	2	4	3.0	B
4	45	95	55	65	B	B	B	C	B	3	3	2	2.7	B
5	45	85	70	67	B	B	C	B	B	3	2	3	2.7	B
6	40	95	50	62	B	B	B	C	B	3	3	2	2.7	B
7	40	80	50	57	C	B	C	C	C	3	2	2	2.3	C
8	35	70	65	57	C	C	D	B	C	2	1	3	2.0	C
9	35	85	45	55	C	C	C	C	C	2	2	2	2.0	C
10	30	75	60	55	C	C	D	B	C	2	1	3	2.0	C
11	30	80	50	53	C	C	C	C	C	2	2	2	2.0	C
12	30	90	75	65	B	C	B	B	B	2	3	3	2.7	B
13	25	95	30	50	C	C	B	D	C	2	3	1	2.0	C
14	25	90	60	58	C	C	B	B	B	2	3	3	2.7	B
15	20	90	55	53	C	C	B	C	C	2	3	2	2.3	C
16	20	85	55	53	C	C	C	C	C	2	2	2	2.0	C
17	20	80	35	45	D	C	C	D	D	2	2	1	1.7	D
18	15	100	50	55	C	D	A	C	C	1	4	2	2.3	C
19	15	65	40	40	D	D	D	D	D	1	1	1	1.0	D
20	10	80	45	45	D	D	C	C	D	1	2	2	1.7	D
21	10	85	35	43	D	D	C	D	D	1	2	1	1.3	D
22	5	85	45	45	D	D	C	C	D	1	2	2	1.7	D
23	5	60	30	32	F	D	F	D	F	1	1	1	0.7	F
24	0	75	75	33	F	F	D	F	F	0	0	0	0.3	F

terms of figures from 0 to 100, recording these figures and finally averaging them. This method has little justification. The manipulations of large figures takes too long a time, even when one has an adding machine at his disposal.

The second method consists of recording the letter grades. It is satisfactory, except when it comes to averaging up the records. With only three examinations to average there is no trouble, but if one has to average ten grades, how shall he do it? For example, how would you finally grade students who received (a) A, B, C, C, D, B, C, C, F, and B and (b) B, B, C, D, B, D, C, C, C, and A? The easiest method of keeping one's record book and a method as reliable as any other is that shown as the third method in Table XII. The letters A, B, C, D, and F are represented in the record-book by the figures 4, 3, 2, 1, and 0, respectively. (Figures are easier to write than letters to begin with, and they can readily be averaged. Contrast the labor involved in averaging

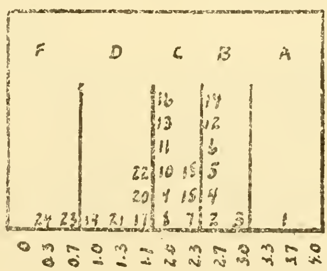


Plate XXII. The final grades, computed according to the third method in Table XII, plotted in a surface of distribution.

them with that of averaging the figures employed in the first method.) Averages between 0 and 0.5 would then be graded F; between 0.5 and 1.5, D; between 1.5 and 2.5, C; between 2.5 and 3.5, B; and between 3.5 and 4, A. This scheme tends, however, to give too many C's and too few of the other grades. A better method is as follows: Before making out one's final grades, plot the average grades in a surface of distribution as shown in Plate XXII, and award the final grades according to their position on that surface.

A comparison of the letter grades awarded in Plates XXI and XXII shows that they are almost identical. The laborious attempt at great accuracy pursued in the first method of recording grades (See Table

XII and Plate XXI) gives practically the same results as those obtained by the easier third method (See Table XII and Plate XXII). And in the case of Student 14, after all, which is the fairer grade for him, a "C" or a "B"?

CONCLUSION.

We are graded in life not according to some ideal standard of perfection, but in comparison with our fellows, particularly our competitors. Edison is great, not because he approximates perfection but because he is superior to other men. Our minister, or lawyer, or music teacher, or grocer is superior or inferior in comparison with other ministers, lawyers, music teachers, or grocers we know. We have no standards of perfection as such. Even in the few cases where we do have standards, as in track athletics, we honor the winner of the hundred yard dash in a great track meet, even if the time was only 10 1-5 seconds, altho that is far from the world's record.

LESSON 29—HOW MAY ONE DIAGNOSE THE ABILITY OF CHILDREN?

In Lessons 23 and 24 we made a general study of the causes of individual differences. The general laws underlying this subject were illustrated with results obtained by averaging the data from a class of adults, a class of normal 4th Grade children, and a class of mentally defective children. These average results were treated as tho they were representative of three individuals of varying degrees of hereditary endowment and training.

Today we wish to carry this study further. We shall have before us the actual learning curves of several children and we shall endeavor to ascertain what we can about the hereditary equipment and previous training of these children from the curves themselves. The lesson will serve as a review in the sense that previously learned material on this subject will needs be recalled to mind; it will also serve as an advance lesson in that what has been previously learned must now be utilized in a new way.

In Plates XXIII to XXVI are given the individual learning curves of eight members of the 4th Grade class previously studied in Lesson 24. They are all drawn so as to show the number of problems solved correctly in one minute. (They actually worked two minutes and the scores reported here are one-half of what they did in that interval of time.) The solid line represents the learning in Test B—addition, while the broken line represents the learning in Test BX—multiplication. In the first curve (A) the little girl advanced from 24 problems in addition to 40 in one minute and from 16 problems to 31 in multiplication.

ASSIGNMENT.

1. In the light of what you already know about how heredity and training affect learning curves endeavor to formulate just as definite comparisons as you can concerning these eight children. Arrange them in order according to their previous training, also in order according to their innate ability. Defend your position.

2. Which pupil, if any, would you put in a lower grade? Why?

3. Do you note any peculiarities in these curves—characteristics that you have not previously discovered? If so, explain them.

(Three of the learning curves in addition stop before 15 trials were made. This is due to the fact that the children were transferred to a subtraction test as soon as they could do the whole addition blank (i. e., 80 problems) correctly in two minutes.)

Write up your results in the usual way and hand them in at the next class hour.

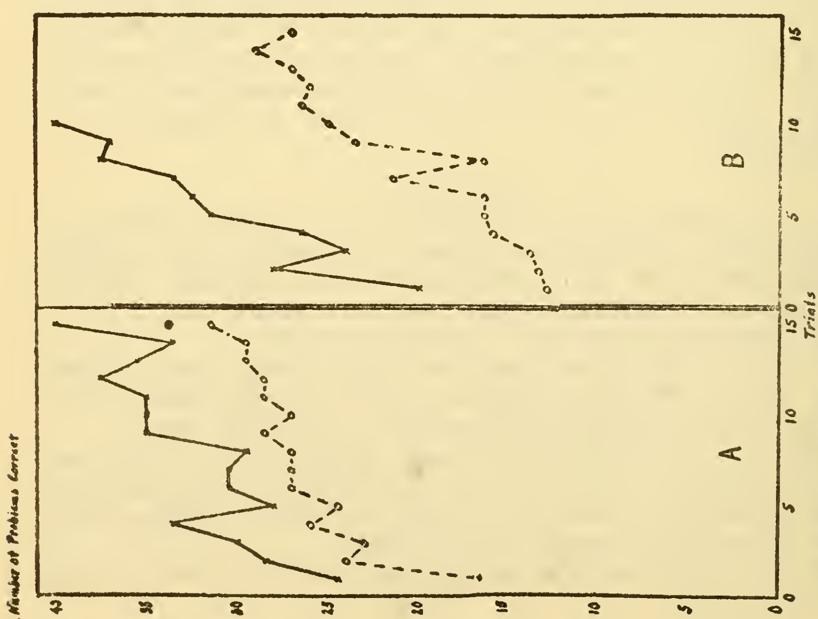


Plate XXIII. Learning curves of two children (A and B) in the 4th grade in Tests B (shown in a solid line) and BX (shown in broken line).

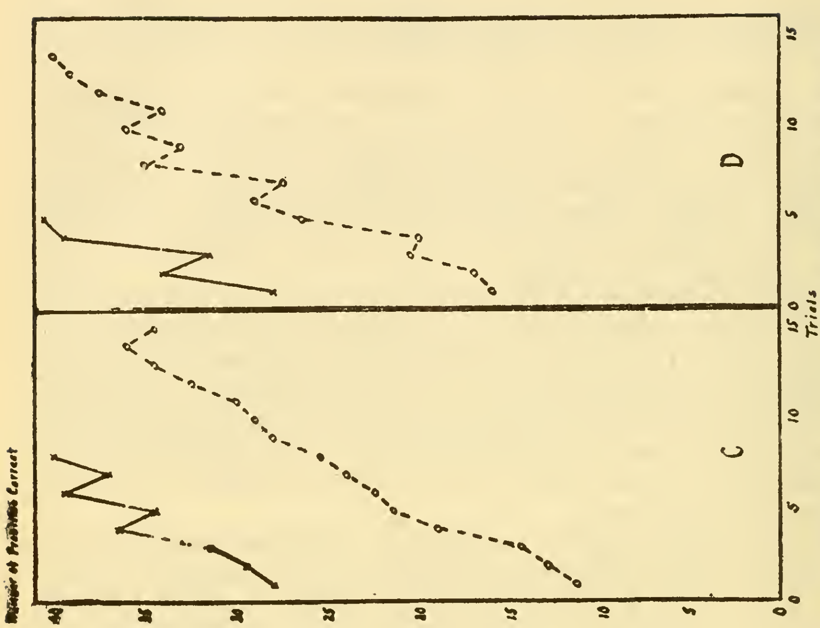


Plate XXIV. Learning curves of C and D in Tests B (shown in a solid line) and BX (shown in a broken line).

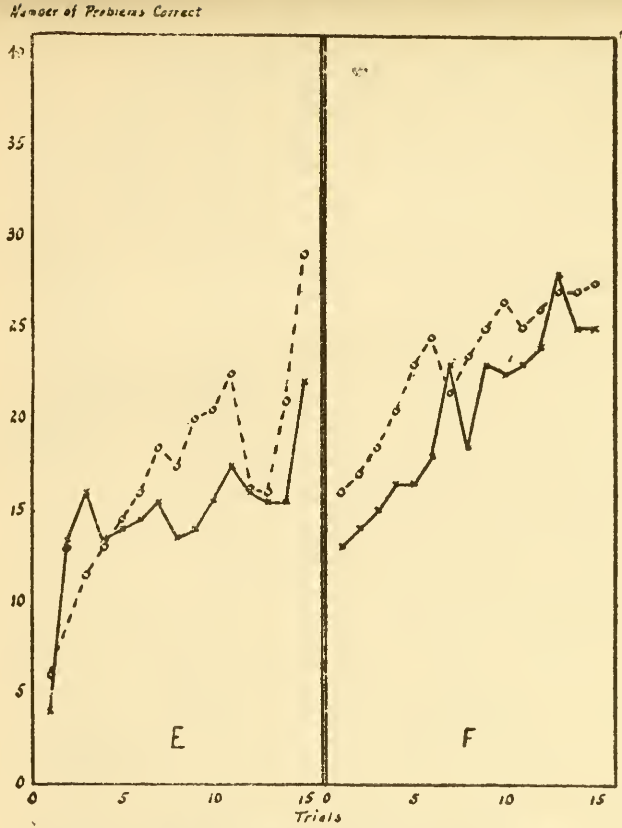


Plate XXV. Learning curves of E and F in Tests B (shown in solid line) and BX (shown in broken line).

Plate XXVI. Learning curves of G and H in tests B (shown in solid line) and BX (shown in broken line).

LESSON 30—THE EFFECT OF HEREDITY AND TRAINING ON LEARNING*

THE USE OF LEARNING CURVES IN TEACHING.

In Plates XXIII to XXVI are given the learning curves of eight children from the fourth Grade, and in Plate XII is given the average curve for the entire class. These curves represent the improvement that took place in simple addition and multiplication as the result of 4 minutes of actual school work on 15 different days. There is no doubt, however, that many of the children practised on such work outside of school. Nevertheless the improvement shown is little less than marvelous when compared with what is ordinarily obtained in school in such a length of time. It is only fair to add in this connection that considerably more than 4 minutes of the school time was consumed in the work, since it takes time to give out and collect test papers. Besides, the children were called upon to correct their papers and plot their own learning curves. But part of this additional time must be credited to teaching the children how to draw learning curves and their meaning—a most valuable lesson.

Much of the surprising gain registered is due not to the use of the test-blanks themselves, altho they are valuable adjuncts to teaching, but to the fact that the children could see day by day just how they were improving. They showed the greatest interest possible in the work and long after the writer had ceased the tests he was waylaid by the children and asked to renew them.

One of the greatest needs today in our educational work is to provide adequate means of registering the daily improvement of the students. If one can see himself improving he becomes very much interested and consequently does very much better work. The use of such curves as employed here enables a child not only to race against others but to race against himself. If he loafs, his curve shows it very clearly; if he works very hard, the curve registers that fact. Ordinarily only the superior children can obtain the thrill of winning in a scholastic race as school work as usually administered. But with the use of learning curves a dull child at the bottom of the class may experience the feeling of victory when he sees his curve rise. The presence or absence of a feeling of confidence in oneself may account for many of the successes or failures in life.

*CLASS-HOUR	IN CLASS	WRITE UP	READ
30	Discuss, Lesson 29		Lesson 30
31	Experiment, Les. 31	Lesson 31	

As an example of just how a learning curve may be used to great advantage the following case supplied by Miss Martha Carroll is of interest.

"After a year and a half of unsuccessful attempts to stimulate anything worthy of the name of effort in an eleven year old boy pupil, I decided to make an attempt at a learning curve of some sort. The subject being music (and violin at that) it semed almost an impossibility to figure out a method by which a record might be kept and exact progress noted. As an exact record of progress made, the curve (See Plate XXVII) is a failure, but it accomplished its purpose of stimulating an effort.

"The lessons were 45 minute periods once a week—30 minutes being devoted (approximately) to the lesson assigned the previous week and 15 minutes to the new lesson. The record was kept during the period of assigned lesson only, any errors in the new lesson being left uncounted.

"The understanding with the pupil was, that for every correction I must make during the 30 minute period a mark would be made—these marks to be counted and stand for the grade at the end of the lesson. It was also agreed that no error noticed, and corrected by the pupil should be counted against him. The errors were to include those of position, intonation and rhythm—accuracy being the sole end in view.

"At the first lesson where the record was kept I made 40 corrections during the 30 minutes. For the first time, the child became aware of the fact that he did not 'know everything about it,' and that he was *not* 'doing it right'. He became intensely interested, and from then on watched like a hawk every mark made against him and was very soon seeing his own mistakes and correcting them before I had a chance to do so.

"The first record was made on Feb. 22, 1916, and on May 23, 1916, the final record was made; the score having been reduced from 40 errors to 5 at the lowest record—and closing with a score of 10 errors. That the actual amount of progress made is not evident, may be seen from the fact that at the time of the last record fully 3 1-3 times as much ground was covered in the 30 minutes as at the time of the first record, thus reducing considerably the percentage of errors at the final record.

"The change was entirely one of attitude, for the amount of actual practise time spent between lessons was *not* increased.

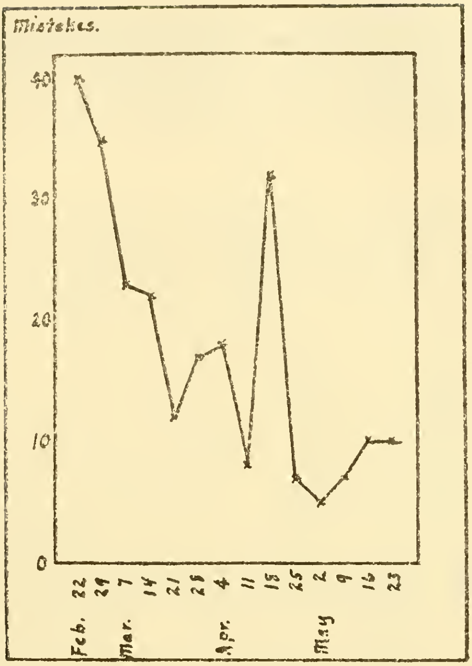


Plate XXVII. Curve showing progress in eliminating errors in learning to play the violin.

"The sudden rise in the curve at the ninth record I attribute to a return of the original attitude of self-satisfaction."*

DIAGNOSIS OF INDIVIDUAL ABILITY ON THE BASIS OF LEARNING CURVES.

Turning now from a discussion as to the general usefulness of learning curves in teaching, let us consider the questions as assigned in the last lesson.

Question 1. *Arrange the six children in order (a) according to their previous training, and (b) according to their innate ability.* Their initial ability can be taken as a fair representative of their previous training. The term "previous training" must needs refer not to hours of instruction received, but to the amount of instruction that has been absorbed and is now at the disposal of the child. According to this interpretation of the term a bright child with ten hours instruction might make a better initial showing than a

*A very good example of how such methods have been utilized in industrial work is recorded by R. B. Wolf in "The Creative Workman," published by the Technical Association of the Pulp and Paper Industry.

dull child who has had sixty hours instruction. In that case we would say the bright child has received greater training. Not so much instruction (in hours) has been bestowed upon him, but he has absorbed more. With this point in mind we can see all agree in arranging the eight children as to previous training in the following way:—

TABLE XIII. SHOWING ARRANGEMENT OF EIGHT CHILDREN ACCORDING TO THEIR PREVIOUS TRAINING IN ADDITION (B-TEST) AND MULTIPLICATION (BX-TEST) AND IN THE TWO TESTS TAKEN TOGETHER

	Addition		Multiplication		Two Taken Together
1.	C	28	A	16	D
2.	D		D		A
3.	A	24	F		C
4.	B	20	B	13	B
.	H		C	11	F
6.	F	13	E	9.5(6)	H
7.	E	8.5(4)	H	6	E
8.	G	8	G	2	G

The curves of E are unusual in that there is such a great gain between the first and second trials and between the fourteenth and fifteenth. Such a condition is possible but unlikely, especially when the rather slow progress between trials two and thirteen is taken into consideration. The writer has interpreted the curves to mean that the little girl was "rattled" on the first day and so did not do what she could do. He has consequently estimated her initial record as the average of her first two records, i. e., as 8 1-2 and 9 1-2 instead of 4 and 6. From all that is known of the child this seems to be a fairer interpretation than to use the records just as they stand. The unusual gain at the last performance suggests cheating. There is no way of knowing whether she did or not. Before diagnosing her properly further trials should be obtained. As this cannot be done we shall have to accept the record as it stands.

In estimating innate ability one must take into account the slope of the curve and how near it approaches the physiological limit (See Plate IX). Of two children having curves of equal slope, the one whose curve more nearly reaches the physiological limit is the brighter child. With these points in mind the writer would arrange the children for innate ability as shown in Table XIV.

TABLE XIV. SHOWING ARRANGEMENT OF EIGHT CHILDREN ACCORDING TO THEIR INNATE ABILITY IN ADDITION (B-TEST) AND MULTIPLICATION (BX-TEST) AND IN THE TWO TESTS TAKEN TOGETHER

	Addition	Multiplication	Two Taken Together
1.	D	D	D
2.	C	C	C
3.	B	E	B
4.	A	A	A
5.	E	B	E
6.	F	F	F
7.	G	H	H
8.	H	G	G

In estimating the average of the two, the fact that E, A, and B were about equal in their gains in multiplication but not in addition influenced the writer in arranging them finally in the order B, A, and E.*

Before passing to a consideration of questions 2 and 3 in Lesson 29, it will be worth while to check up the estimate given above with other records of these children. Their scholastic record as based on their final grades for that semester and the opinion of their teacher and principal, who knew them personally, ranks them as follows in the class of 28 children.

*L. L. Thurstone in The Learning Curve Equation, Psychological Review Monograph, 1919, discusses the theory of learning curves and suggests a formula to cover them. The writer has found the following very simple formula will enable one to estimate fairly well the relative innate ability of children on the basis of their performance:—ability $= \frac{1}{2}$ (Initial Score + Final Score) $\times$Gain.

This equation takes into account the steepness of the slope (gain) and in a very crude way the approximation of the curve to the physiological limit. Using this formula we would obtain the rank of these children and their scores as given in the Table below. In order to use this formula in the case of the three children B, C, and D it is necessary to estimate how many problems they would have done in Test B if they had been permitted to work at the test for 15 trials. The estimates made are as follows: B, 48 problems at trial 15; C, 51 problems; and D, 57 problems. The estimate for D in multiplication for the fifteenth trial is 41 problems.

Table Showing Arrangement of Children According to Innate Ability as Based on the Above Formula.

	ADDITION			MULTIPLICATION			AVERAGE OF TWO
1	D, 42.5	×29	=1232*	D, 28.5	×25	=712	D, 972
2	B, 34	28	952	C, 23	24	552	C, 730
3	C, 39.5	23	908	E, 19	19.5	370	B, 616
4	A, 31	16	496	A, 23.5	15	352	A, 424
5	F, 19	12	228	B, 20	14	280	E, 286
6	E, 15	13.5	202	F, 21.5	11	236	F, 264
7	G, 11.5	3	34	H, 14	16	224	H, 112
8	H, 20	0	0	G, 6.5	9	58	G, 46

*This figure is obtained as follows:—The sum of the initial record (28) plus final record (57, estimated) is 85. That amount divided by 2 and multiplied by 29 (the gain, i. e., 57 — 28) equals 1232.

Children	Rank in Class	Promotion Record
A	1st	Passed to 5A
B	2d	"
C	3d	"
D	4th	"
E	25th	Passed to 5B
F	26th	Passed on condition
G	27th	Dropped out of school
H	28th	Passed on condition

At the time these Learning Curves were obtained the class was tested with the Courtis Arithmetic Tests (See Lesson 26 for reference to these tests). Their relative standing computed on the basis of a class of 100, instead of 28 would be:—

Courtis Arithmetic Tests	A	B	C	D	E	F	G	H
Addition	24	26	39	11	86	64	89	83
Subtraction	7	29	57	32	92	88	89	26
Multiplication	50	51	47	4	75	92	94	75
Average	27	25	48	16	84	81	91	61

A here stands 24th in her class in the addition test, 7th in subtraction and 50th in multiplication, averaging 27th. The relative rank of five of the eight children was obtained a year later; the other three children having left school. Again these results are expressed as the ranking of the child on the basis of a class of 100.

Courtis Arithmetic Tests	A	B	C	D	E	F	G	H
Addition	—	—	46	4	95	—	—	95
Subtraction	—	—	14	21	82	—	—	97
Multiplication	—	—	60	13	97	—	—	75
Division	—	—	13	23	98	—	—	83
Woody Arithmetic Tests								
Addition	—	—	9	63	75	—	—	73
Subtraction	—	—	10	53	81	—	—	100
Multiplication	4	—	13	—	60	—	—	99
Division	4	—	3	29	59	—	—	92

Strong Arithmetic Tests								
Addition (B)	19	—	7	19	92	—	—	7
Multiplication (BX)	15	—	15	3	19	—	—	10
Average of 10 Tests	11	—	19	23	76	—	—	73

Clearly, then, learning curves such as produced by A, B, C, and D are typical of bright capable children while those curves produced by E, F, G, and H are typical of children who stand near the bottom of their class. The curve of G is the poorest from the point of initial score or slope. This child never belonged in the 4th Grade and so dropped out of the school as there was no room for him in the 3rd Grade.

Question 2. Which pupil, if any, would you put in a lower grade? Why? This question has already been answered above. G shows markedly inferior knowledge of addition and multiplication and his curves show that he cannot learn rapidly. In fact he learns more slowly than other children in the same grade. There is then no chance of his catching up with his class. Instead he is going to be left farther and farther behind.

Question 3. Do you note any peculiarities in these curves—characteristics that you have not previously discovered? If so, explain them. H's addition curve is very striking and unusual. As she improved in multiplication she lost in addition. In this instance there was a clear case of *interference*, i. e., the habit of "seeing 4×3 and thinking 12" was interfering with the habit of "seeing $4+3$ and thinking 7." She continued in this condition for some time afterwards. Later in the year she was put thru another practise series. The addition again showed an interference effect from the multiplication. Finally she overcame this interference and eventually after three months of individual drill reached a speed of 40 problems in one minute in both addition and multiplication and a good speed in subtraction and column addition. But she has shown no ability to solve ordinary problems in arithmetic. A year later she made the records recorded above, showing that she had retained what she had learned in the B and BX Tests but was extremely poor in more complicated arithmetic work. Our present diagnosis is that she will never be able to solve problems requiring reasoning.

THE RELATIONSHIP OF THE PROBLEM OF INDIVIDUAL DIFFERENCES TO EDUCATION.

The problem of individual differences is a very big problem in the educational world and must be taken into consideration in teaching and

administrative work. Children differ very materially. Such differences are caused jointly by heredity and by training. The differences in training can to a large degree be taken care of thru putting those with extra training ahead of those with less training. But the differences due to heredity cannot be disposed of so easily. Superiority in heredity means that the child is going to advance rapidly, inferiority in heredity means that the child is going to advance slowly. This is shown diagrammatically in Plate IX. It means that any class is always going to fly apart. The more training a group has the more the children are going to become unlike. Training does not make people alike, it makes them unlike. The bright child gets all of his lesson, the dull child but half. The next day the bright child gets all of the new lesson, the dull child cannot do as well as he did before, because part of the new lesson depends on that part of the first lesson he didn't get. He consequently gets less than half of the second lesson. So as time continues the gap between the two widens.

As things are conducted today, average children are fairly well taken care of. The pace set is too slow for the bright children and too fast for the dull children. The bright children are not encouraged to work hard. They can easily get their lessons in a few minutes "any old time." The dull are discouraged for they can't possibly keep pace. What is needed today is a system so elastic that all can keep working at their own pace. Some advocate here that the pace be set for the dull child and the better children be persuaded to do more work on the side and in a better manner. The dull child will then get the sheer essentials, the others a richer and richer course depending on their ability. But how is such a course to be conducted? Others advocate various schemes for rapid or slow promotion depending on the different children.

The Courtis Standard Practise Tests. In this connection the Courtis Standard Practise Tests should be borne in mind. These tests are different from the Courtis Arithmetic Tests already mentioned several times.

The first two tests and the record sheet covering these tests are shown in Plates XXVIII and XXIX. On the first day every child is given a copy of lesson 1. Suppose it is a 4th Grade class. The children are then allowed 6 minutes to do the lesson.* At the end of the six minutes the papers are corrected and each child records his record in his Record Book. On the second day, if any child finished the first lesson correctly within the six minutes he is not required to

*The other grades are given a shorter time. The 5th grade is allowed 4¾ min.; the 6th grade 4 min., the 7th grade, 3½ min., and the 8th grade, 3 min.

do Lesson 1 over again but is supplied with Lesson 2 instead. The remainder of the class repeat Lesson 1. So it goes thruout the year. It is conceivable that after forty-eight days a very bright child would have entirely finished all 48 lessons whereas a very dull child would still be on the first lesson. Professor Courtis, however, advocates that after several failures, individual instruction be given the backward child and if that is not sufficient to bring him up, that he be allowed to go to the next lesson. In Plate XXIX are shown two individual records on the one sheet. (Ordinarily only one record would appear on a page.) N has required 15 days in which to finish Lesson 1. The

LESSON No. 1—ADDITION

Name____________________ Grade________

6	8	4	2	5	6	4	3	4	4	9	5
3	4	7	4	0	7	2	6	9	2	6	0
1	7	4	6	2	5	3	8	6	9	8	6
1	8	3	7	7	1	5	5	5	1	8	7
8	1	4	2	0	7	2	1	9	3	7	5
3	5	9	4	1	7	6	9	2	9	8	2
6	5	3	7	8	1	6	8	6	4	3	7
5	2	9	5	0	8	7	1	2	8	8	6
5	6	8	4	8	9	6	3	1	5	7	6
9	7	4	9	9	5	5	2	4	7	3	8
3	0	4	7	6	6	1	4	5	2	9	9
2	4	8	3	5	9	6	8	9	8	9	3
4	3	4	5	9	4	4	1	5	9	6	5
7	4	9	1	7	9	3	3	1	2	5	4
4	8	7	8	0	3	1	8	5	3	8	7
8	9	5	8	5	3	3	5	9	1	3	8
4	3	0	8	3	6	3	6	7	6	9	6
0	6	8	5	2	4	1	8	5	7	4	0

LESSON No. 2—SUBTRACTION

Name____________________ Grade________

19	32	14	32	12	23	35	13	31
6	7	2	3	2	9	7	1	4
15	17	33	19	30	27	16	26	26
5	2	7	8	2	7	2	7	5
21	37	12	29	25	28	18	27	26
8	9	1	5	9	1	3	6	8
29	18	31	20	32	14	17	37	24
9	5	6	9	6	4	3	8	7
13	38	31	27	21	19	24	14	30
2	8	7	5	5	1	5	3	3
21	33	20	29	32	15	26	30	
2	8	1	3	4	4	6	6	
18	28	14	29	11	32	23	15	
2	9	1	4	1	9	6	1	

Plate XXXVIII. Courtis Standard Practice Tests.*

solid line traces the number of problems he did each day and the broken line the number he got correct. M, on the other hand, finished Lesson 1 in five days and Lesson 2 in two more days. (As there are but 61 problems in Lesson 2, 61 is of course the standard set in that lesson.) His record for Lesson 3 would be scored on another page and so does not appear here. He finished up four lessons while M was doing one.

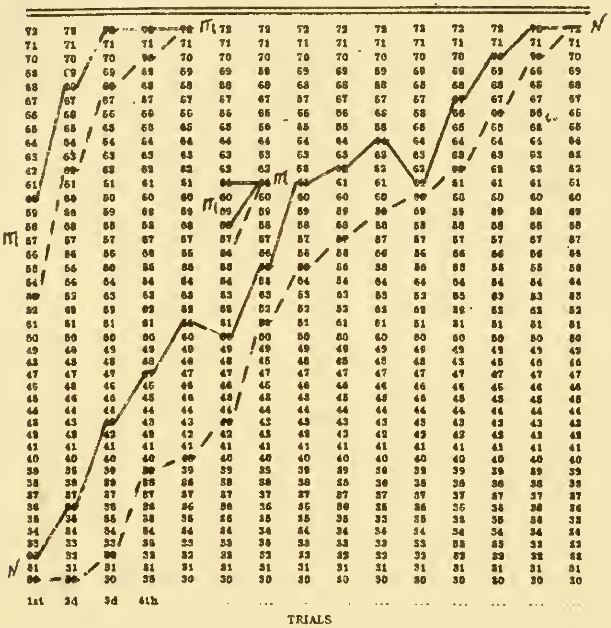
*The latest edition of these practice tests shows Lesson No. 1 as above. But Lesson No. 2 now comprises 70 problems instead of 61. The Graph Sheet in Plate XXIX is also from an earlier edition of the "Student's Record and Practice." (By permission of World Book Company.)

GRAPH SHEET

FOR

Lesson No. 1 . . 72 examples Lesson No. 2 . . 61 examples

LESSON NO.



INSTRUCTIONS: After each trial, in the column corresponding to the number of the trial, draw a short horizontal line through your score in examples tried. Using a ruler, draw a heavy line from this point to the score marked in the previous column. In like manner draw a curve for Rights, using a heavy broken line. More than one graph can be drawn on this page; see Model, page 4. When you have completed the lesson successfully, hand in this record book with your paper.

Plate XXIX. Graph sheet. Showing record of two children, M and N. M finishes lesson No. 1 in 5 days and Lesson No. 2 in two days more. N requires 15 days to complete Lesson No 1 in the allotted time.

The point to be noted about this scheme is that it provides a method by which the entire class can be put at arithmetical work and at the same time the lessons may be varied in accordance with individual differences. Moreover each child plots his own learning curves and so knows just how he is advancing day by day. He has the stimulation of racing against others and also against himself.

INDIVIDUAL DIFFERENCES PROVIDED FOR IN THIS COURSE IN PSYCHOLOGY.

An entirely different scheme for providing for individual differences is utilized in this course. Each lesson contains as many "leads" as even the best student will have time to follow. Every minute devoted to study adds something additional to his training or store of information. At the same time each lesson is easy enough so that the poorest student, deserving only to pass the course, can obtain sufficient grounding in the fundamentals of the course to pass and go on. The better the student, the more thorough a grasp of the material will be obtained, but all will get a worth while amount. If two or three times as much time was devoted to the course, the poorer students would get more from the course, but the better students would not be kept busy and so would not get the maximum training they have a right to receive in return for their tuition and time.

LESSON 31—HOW MAY SUCH PROPOSITIONS AS "RELATIONSHIP OF INITIAL TO FINAL PROFICIENCY" BE ACCURATELY INVESTIGATED?

In Lesson 21 a preliminary study was made as to whether those who were best at the start were best at the end in such training as doing the mirror-drawing experiment. After we had arranged the ten individuals A to J (See Table IV) with respect to their initial and final abilities we found it difficult to express just what the relationship between the two orders was. In this lesson we shall attempt a more satisfactory study of this point.

So far we have considered the average and the average deviation as measurements which help us in our study of individual differences. Still another measurement is needed:—the *coefficient of correlation.* This measurement is needed when we attempt to compare the order of superiority of a group of individuals at one time with their order obtained at another time. For example, in the results obtained from Lesson 21, just what is the relationship between the two orders? On the whole, we can see that those who are best at the start are best at the end; still there are exceptions. And if, instead of B holding 1st and 4th positions, respectively, he held 1st and 10th positions (i. e., had a final score of 90), we would find it extremely difficult to state just how this change had really affected the entire relationship between the two sets of figures. Here are these two cases:—

CASE I. (Based on Actual Data)				CASE II. (B's Data Altered)			
Initial	Ability	Final	Ability	Initial	Ability	Final	Ability
B	(76)	G	(35)	B	(76)	G	(35)
I	(129)	J	(36)	I	(129)	J	(36)
J	(131)	I	(40)	J	(131)	I	(40)
C	(210)	B	(50)	C	(210)	E	(52)
E	(216)	E	(52)	E	(216)	C	(58)
A	(232)	C	(58)	A	(232)	H	(60)
G	(283)	H	(60)	G	(283)	A	(61)
F	(286)	A	(61)	F	(286)	F	(70)
D	(363)	F	(70)	D	(363)	D	(85)
H	(701)	D	(85)	H	(701)	B	(90)

From a study of the two sets of relationships it is clear that there is a closer relationship in the first case than in the second. But it is impossible to estimate this difference by looking at all the figures. We need some clear and definite method of expressing such relationships. This is exactly what the coefficient of correlation gives us. Below is an example fully worked out. Study it carefully so as to be able to obtain the coefficient of correlation in similar examples yourself.

HOW TO OBTAIN A COEFFICIENT OF CORRELATION.

The several steps involved in obtaining a coefficient of correlation are as follows:—

1. Arrange your individuals in order of merit in the two cases to be studied. (If two or more individuals are tied, then the following scheme is to be followed. Suppose 10 children received these grades in arithmetic—A, 100; B, 90; C, 90; D, 85; E, 80; F, 80; G, 80; H, 80; I, 75; and J, 70. Then rank A as 1; B and C as 2½ (i. e., the average of 2 and 3); D as 4; E, F, G, and H as 6½ (i. e., the average of 5, 6, 7 and 8); I as 9; and J as 10).
2. Obtain the differences in the *rank* of each individual in the two ratings (d).
3. Square these differences (d^2)
4. Obtain the sum of these squared differences (Σd^2)
5. Multiply this sum by 6 ($6\Sigma d^2$)
6. Count up the number of individuals being studied (n), square this number (n^2), subtract 1 from that (n^2-1), and then multiply the difference by the number ($n(n^2-1)$).
7. Divide the amount obtained in the 5th step by the amount obtained in the 6th step.
8. Subtract this decimal from 1.00, observing algebraic signs. This final decimal is the coefficient of correlation.

Here is the solution of the coefficient of correlation of the first set of figures.

Initial Ability		Final Ability		Individual Considered	Differences in Rank	Differences Squared
Rank	Individual	Rank	Individual			
1	B	1	G	B	1—4 = —3	9
2	I	2	J	I	2—3 = —1	1
3	J	3	I	J	3—2 = 1	1
4	C	4	B	C	4—6 = —2	4
5	E	5	E	E	5—5 = 0	0
6	A	6	C	A	6—8 = —2	4
7	G	7	H	G	7—1 = 6	36
8	F	8	A	F	8—9 = —1	1
9	D	9	F	D	9—10 = —1	1
10	H	10	D	H	10—7 = 3	9
					Total	66

Formula for coefficient of correlation (the letter "r" is the common abbreviation for this term) :—

$$r = 1 - \frac{6 \Sigma d^2}{n (n^2 - 1)}$$

d^2=the differences squared, illustrated by the ten squared deviations in the last column.

$$r = 1 - \frac{6 \times 66}{10 (100 - 1)}$$

Σd^2=the sum of all the squared deviations, as 66 above.

$$r = 1 - \frac{396}{990}$$

n=the number of individuals being considered, as 10 in this case, the 10 individuals, A—J.

$r = 1 - 0.40$

$r = +0.60$

The coefficient of correlation (r) between initial ability and final ability in the case of these 10 individuals is +0.60.

Here is the solution of the coefficient of correlation of the second set of figures above.

Rank	Initial Ability	Final Ability	Difference in Rank	Differences Squared
1	B	G	—9	81
2	I	J	—1	1
3	J	I	1	1
4	C	E	—1	1
5	E	C	1	1
6	A	H	—1	1
7	G	A	6	36
8	F	F	0	0
9	D	D	0	0
10	H	B	4	16
				138

$$r = 1 - \frac{6 \Sigma d^2}{n(n^2-1)} = 1 - \frac{6 \times 138}{10(100-1)} = 1 - \frac{828}{990} = 1 - 0.84 = +0.16$$

WHAT A COEFFICIENT OF CORRELATION MEANS.

"Correlation expresses to what extent two traits vary coordinately, independently, or antagonistically."* For example, scholarship varies coordinately with intelligence, independently of an alphabetic list of the class and antagonistically to the presence of ill health. In other words, (1) the best scholar is most likely to be the brightest child in the class, the poorest scholar to be the dullest child in the class; (2) the best scholar is no more likely to be the student whose name is Aaron than Zullen, and the same is true respecting the poorest scholar; (3) the best scholar is most likely to be the child with the least sickness, while the poorest scholar is most likely to be the child with the most sickness.

A coefficient of correlation of +1.00 means that the two traits vary coordinately and perfectly so; a correlation of +0.75 means that the traits vary coordinately but not perfectly so; a correlation of 0 means that the two traits vary independently; and a correlation of —1.00 means that the two traits vary antagonistically. Coefficients of correlation range, then, from +1.00 thru 0 to —1.00; any single number having a certain significance on a scale from coordinate variability, thru independent variability to antagonistic variability.

The correlation of +0.60 which was obtained between initial performance and final performance in the mirror-drawing experiment means that on the whole the best at the start was best at the end, the poorest at the start was poorest at the end, the fifth at the start was fifth at the end, etc. If it had been exactly this relationship we would have had a correlation of +1.00. As we had less than +1.00, i. e., +0.60, it means that a few of the individuals were out of place from this perfect arrangement. This we find in the cases of G, B, and H; G advancing from seventh to first place, B dropping back from first to fourth place, and H advancing from tenth to seventh. Besides these decided changes in position, all the other individuals except E change place to a slight extent. Now in the case of our second case with its correlation of +0.16 we have a statement which indicates that there is practically no relationship between the two sets of figures. We can expect that only to a very slight extent will it be true that the best at the start will be the best at the end and the poorest at the start will be poorest at the end. Rather will we expect to find decided differ-

*Joseph Jastrow, Character and Temperament, 1915, p. 509.

ences between the two groups of figures such as B's change from first to last place, G's change from seventh to first place, and H's change from tenth to sixth place.

ASSIGNMENT FOR LABORATORY HOUR.

Obtain the coefficient of correlation for the problems given below. Do as many of these problems as you can during the laboratory hour. Check up your answer for each example, thru consultation with the instructor, before going on to the next problem.

Records of Ten Individuals in Mirror-Drawing Experiment.

Trials	A	B	C	D	E	F	G	H	I	J
1	232	76	210	363	216	286	283	701	129	131
5	133	70	108	132	110	97	76	98	84	75
10	88	54	71	121	75	89	56	72	55	49
15	89	53	60	86	75	81	43	55	59	38
20	61	50	58	85	52	70	35	60	40	36

1. Obtain the correlation between the fifth performance and the final performance in the mirror-drawing experiment.

2. Obtain the correlation between the tenth performance and the final performance.

3. Obtain the correlation between the fifteenth performance and the final performance.

4. Suppose the following grades had been given to ten students in High School, what would be the correlation between their grades in (a) algebra and English, (b) algebra and Latin, and (c) algebra and biology?

	Algebra	English	Latin	Biology
A	98	A	F	83
B	96	A—	D—	94
C	93	B+	D	86
D	89	B	C—	72
E	85	B—	C	91
F	84	C+	C+	88
G	82	C	B—	69
H	80	C—	B	95
I	75	D	A—	77
J	70	F	A	90

HOW COEFFICIENTS OF CORRELATION ARE UTILIZED IN PSYCHOLOGY AND EDUCATION.

What you have been working on during the last laboratory hour seems far away from psychology. In a sense it is mathematics and not psychology. In another sense it is just as much psychology as any other topic which has been discussed in the course. Let us consider some examples where this mathematics is essential for the development of psychological or educational principles.

The writer in his "Relative Merit of Advertisements"* wished to determine whether the results he had obtained in rating the efficiency

*Edward K. Strong, Jr. Relative Merit of Advertisements, 1911, p. 11-15.

of advertisements by a laboratory method would check up with business conditions. He therefore correlated the results he had obtained by two different laboratory methods with each other and with the ratings of these advertisements as furnished him (a) by the owners of the business and (b) by the advertising agency representing the business concern. He obtained these correlations:—

Correlation between the results of the two laboratory methods	+0.95
Correlation between the results of first laboratory method and the company rating	+0.89
Correlation between the results of first laboratory method and the agency rating	+0.87
Correlation between the results of second laboratory method and the company rating	+0.84
Correlation between the results of second laboratory method and the agency rating	+0.92
Correlation between the company rating and the agency rating	+0.87

Apparently then the laboratory methods of estimating the efficiency of these advertisements were as accurate as the methods of the company or of its advertising experts. That meant that the writer who knew nothing about advertising in those days, nor about this particular business, could determine the efficiency of its advertisements as accurately as could the men who made these things their specialty.

Take another example. Professor Yerkes of Harvard University has recently devised a series of tests (The Yerkes-Bridges Point Scale Test) whereby the general intelligence of children can be estimated surprisingly accurately. Professor Garrison* tried the tests on college students and obtained a correlation of only +0.19 between the ratings given the students by the Yerkes test and their college grades: also a correlation of +0.15 between the test ratings and the combined opinions of eight professors as to the students' general ability. Of course neither college grades nor the combined opinions of professors accurately portray the real ability of college students. We all know that. Still they are accurate enough so that if a test does not correlate with them more than +0.19 we judge that the test is practically worthless. This low correlation means, then, that Yerkes' intelligence test is of little value in classifying *adults* in terms of their general intelligence. It is, on the other hand, as already stated, of great value in classifying children.

When Dr. Kelley† attacked the problem of how far he could go in prophesying what a student would do in high school on the basis of

*S. C. Garrison, The Yerkes's Point Scale for Measuring Mental Ability, as Applied to Normal Adults, School and Society, June 23, 1917.
†Truman L. Kelley, Vocational Guidance, 1914.

his records in grammar school, he obtained the correlations between the student's grades in the 4th to 7th grades (a 7-year grammar school was studied) and in the first year of high school. The final correlation was found to be +0.79 between grammar school and high school work. Kelley urges on the basis of his study that the grades of a child should be kept on a card for his entire school career, since they form the very best basis now obtainable from which we can estimate what a child will do in higher schooling. And it is quite likely when we come to know more about vocational guidance that we shall find these records of great value in scientifically guiding boys and girls into the careers for which they are most adapted.

These examples are only three out of hundreds that might be given all going to show how necessary it is to obtain a coefficient of correlation in order to solve many psychological and educational problems. At the present point in this course all that is desired is that you obtain an idea of how the correlation is obtained and something as to what it means. As you progress in your training along psychological and educational lines you will run across this topic again and again and after a time you will commence to feel at home with the subject. What a correlation means is a difficult conception to acquire and cannot be gotten in a few minutes or even in a few hours.

ASSIGNMENT TO BE HANDED IN AT THE NEXT CLASS-HOUR.

1. Finish all the problems given out during the laboratory period.
2. Answer the following questions:—
    a. What does a correlation of +1.00 mean?
    b. What does a correlation of —1.00 mean?
    c. What does a correlation of 0 mean?
    d. Could you have a correlation larger than +1.00 or smaller than —1.00?

3. Study these two statements until you feel that you comprehend somewhat of their meaning:—(1) Two individuals selected at random will have a correlation of 0 with respect to any trait, two brothers will have a correlation of about +0.40 with respect to any trait, and two twins will have a correlation of about +0.80 with respect to any trait. (2) Similarly father and son will correlate about +0.30 while grandfather and grandchild will correlate about +0.16.

Hand in your report drawn up in the usual way at the next class-hour.

LESSON 32—REVIEW*

THE BROADER MEANING OF THE TOPICS CONSIDERED IN THIS COURSE.

Three basic conceptions have so far been presented: (1) all behavior is composed of a Situation, Bond and Response; (2) the process of learning is typified by a learning curve; and (3) individual differences are typified by a normal surface of distribution.

This course has been so constructed as to help the reader form the following bonds:—

Any Situation in life which cannot be immediately reacted to.	——→Situation, Bond, Response ——→	What is the situation? Does a bond exist? What response do I want?
(ditto)	——→Learning Curve ——→	Rapid, then slower learning. Fluctuations. Plateaus, etc.
(ditto)	——→Individual Differences ——→	Normal surface. Majority are average men. Effect of Heredity, etc.

In a more advanced course the complete explanation of the value of such organization of material may be given. Here it is sufficient to point out by way of illustrations that if, when one is confronted by a puzzling problem (situation to which he has no immediate reaction), he will think—"Situation, Bond, Response," "Learning Curve," "Individual Differences," he will very frequently find a satisfactory solution to his difficulty. For in so doing he calls to mind many details of this course which may throw light on his problem.

*CLASS-HOUR	IN CLASS	WRITE UP	READ
32	Discuss, Lesson 31		Lesson 32
33	Review, Les. 1-32		Review, Les. 1-32
34	Examination		Lesson 34
35	Experiment, Les 35	Lesson 35	

Suppose you are the advertising manager of a Toasted Corn Flakes Co. The problem before you is to prepare an advertisement which will sell corn flakes. "Situation, Bond, Response" flashes into your mind. "What's that got to do with selling corn flakes?" you ask yourself. Then comes to mind the query, "What response do I want?" Naturally people buying corn flakes. "What situation will bring about such a response?" First of all, "a situation connected up already with eating." "What is such a situation?" "It will soon be vacation time. I want a vacation situation." "What will it be?" After some pondering you think of the situation, "wife going to the country, husband eats breakfast at home," etc. And you prepare an advertisement with a husband eating breakfast alone at home with a package of corn flakes on the table and a heading, "Wife's gone to the country, but this is a good breakfast."

Suppose again the situation is to pass on an advertisement prepared by an artist depicting Venus de Milo and copy about the wonderful statue and equally wonderful breakfast food. Again, "Situation, Bond, Response" comes to mind. You ask yourself, "will this situation (the artist's advertisement) lead naturally to the response I want, i. e., to make people buy corn flakes?" You can't see how it will so you turn it down. For only most far fetched reasoning can connect "Venus de Milo" with "Corn Flakes."

Suppose you are the employer of a large number of clerks. You have tried a young woman of superior attainments with the idea of eventually placing her in charge of one section of your office. But she isn't making good according to your expectations. The puzzling situation confronting you this morning is whether to continue figuring on advancing her when she has learned a little more or to hire a new woman right away for the position. You need some one to put in charge, right now. The learning curve flashes into mind. "Yes, she learned rapidly at first—an indication of superior attainments and little previous knowledge of the work. But she hasn't progressed for some time—must be on a plateau. What's the trouble? Possibly I can straighten it out and she'll make good." You commence to think of the possible causes—is it wrong attitude? is she trying to advance? doesn't she like the work? is there something in the work she has failed to understand which is preventing her advancement? (The thought "learning curve" unlocks the knowledge you have about learning and makes your study of why she is not progressing much more interesting, for you realize that a change *by you* in the situation confronting her may lead to her proper response.)

Suppose again, you are the employer of girls whose job is to do filing. You are annoyed by the very high turn-over* in your department—much higher than other departments. As you ponder over the situation, "individual differences" comes to mind. "Yes, the individuals are different, they stay with me a shorter time than my other employees. The pay is less, but it is above the average for that type of work. What's the trouble?" You investigate and find nearly all quit to get higher pay, doing other kinds of work. Then "normal surface of distribution" flashes to mind. "Maybe," you think, "I can hire less intelligent women, women who can do filing but can't do more involved things." You stop hiring bright women for this department; instead you hire only dull ones, but dull ones who can alphabetize accurately and rapidly.

It is surprising the number of baffling problems about people which can be solved by the use of these three "formulæ." And to the extent that the habit is formed by you, the reader, of thinking from a situation you can't solve to

(1) Situation, Bond, Response.
(2) Learning Curve.
(3) Individual Differences.

to just that extent you will be enabled to utilize the contents of this course.

PREPARATION FOR THE REVIEW.

The next class-hour (the 33d) will be devoted to a general review of the subject of individual differences. Spend the two hours in reviewing the subject. The 34th class-hour will be devoted to a written examination.

As an aid in reviewing the subject matter and in organizing it so it will be most useful to you in after life write out opposite the three headings (1) Situation—Bond—Response, (2) Learning Curve, and (3) Individual Differences the significant facts you have so far learned.

LESSON 33—WRITTEN EXAMINATION

The next class-hour will be devoted to a written examniation.

It is not expected that you memorize the formula for obtaining the coefficient of correlation. But you should understand how to use it and what it means.

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*"Labor turn-over" refers to the number of employees hired during a year to do the work of the average empolyee.

LESSON 34—GENERAL INTRODUCTION TO SOME PHYSIOLOGICAL ASPECTS OF PSYCHOLOGY

In the foregoing lessons we have considered some characteristics of the learning process and of individual differences. Before going further it will be necessary to stop and consider some physiological aspects of learning. This must be done in order to give us a clearer and more definite idea of some of our terms.

GENERAL PHYSIOLOGICAL ASPECTS OF THE LEARNING PROCESS.

So far in this course we have been content to describe human behavior as a response to a situation, including in this conception the thought of a bond which connects the situation with the response. We have now reached a point where it is necessary to scrutinize these three terms and see to just what they do actually refer. It is evident, when we come to think about it, that in the case where some one says "4 and 6" and I answer "10" that there is no material bond of any sort which connects the "4 and 6" and the "10." A "situation" and a "response" are not then connected together with a "bond" of iron, or wood, or of flesh. How then are they connected together? And what is this "bond" we have so freely talked about? In order to answer these questions and many others of like nature we shall have to turn to the science of physiology for help. We shall have to do this because the process of hearing the "4 and 6" pronounced is a process depending upon the functioning of the ear; also my answering with the word "ten" is a process of moving my mouth and throat; and third, there is a process, it is clear, by which my mouth is made to move after my ear has been stimulated. This last process is due to the functioning of nerve cells which connect my ear with my mouth and throat. Now the science of physiology has for its field of investigation such phenomena as these processes just mentioned and consequently if we wish to understand them more thoroughly we shall have to study its findings.

In this digression from psychology to physiology we shall have but three main problems before us. They are: first, *what is the mechanism by which situations stimulate us?* Second, *what is the mechanism for making responses?* And third, *what is the mechanism by which a situation is connected with its response?* All of this information is needed in order that we may understand better just how situations in every day life can, and do, produce certain responses.

In order to get a bird's eye view of this material let us consider one example in a general way. It is not meant that you should grasp and understand all the details of this example,—they will come after the following sections have been covered—but rather that you here shall ob-

tain an idea of what the whole problem is about. In Plate XXX is illustrated in the simplest way possible the action which results when a pin is stuck into one's skin. "The pin being stuck into the skin of the arm" (at B) can represent the situation; "the arm jerked away" represented here by one muscle (C) is the response; and the two nerve cells, one extending from B to L and the other from E to C form the bond. When the pin is stuck into the skin one or more pain-spots in the skin at that point are stimulated. This nervous stimulation travels over the nerve pathway into the spinal cord. At L the current jumps a tiny gap to the second nerve cell. The stimulation then proceeds from the spinal cord over this second nerve pathway to the muscles of the arm (represented by one muscle here). The stimulation is then transmitted to the muscular tissue, causing it to contract and the arm is moved away. All of the above is called a *reflex act.* The whole thing is done unconsciously and actually is finished before one feels the pain.

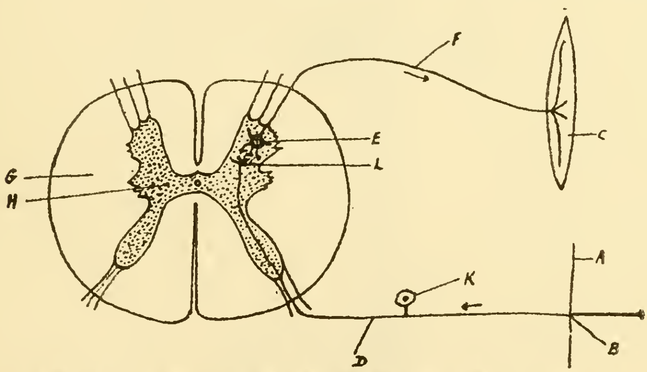

Plate XXX. Diagram illustrating the simplest form of reflex action. The line A represents the outer surface of the skin being pricked by a pin at the point B. D is the sensory nerve-fibre extending from B into the spinal cord and ending in contact with branches from the motor nerve-cell(E). F.is the motor nerve-fibre extending from the motor nerve-cell(E). to the muscle (C). G is the white area in the spinal cord and H the gray matter. K is the sensory nerve-cell of, which D. is a part.

Stimulation at B passes over the sensory nerve-fibre to L, jumps the gap to the motor -cell (E) and then passes,over the motor nerve-fibre to C causing the muscle to contract.

THE THREE LEVELS OF NERVE ACTION.

The nervous process illustrated in Plate XXX involves a sense-organ (pain spot in the skin), a muscle, and nerve cells connecting the two together by way of the spinal cord. Such a process is spoken of as belonging to the "spinal level" of nerve action. When the connection between sense-organ and muscle involves the mid-brain it is

grouped in the "intermediate level"; and when it involves the cortex of the brain, it is grouped in the "cortical level" of nerve action.

The Spinal Level. Connection between sense-organ and muscle takes place in the spinal cord. Such connection has already been described in connection with Plate XXX. It is also illustrated again in Plate XXXI where the stimulation caused by the pin at B causes a current to flow from B to L. Part of this current jumps across the gap to E and then flows on from E to C resulting in the muscle moving (arm jerked away).

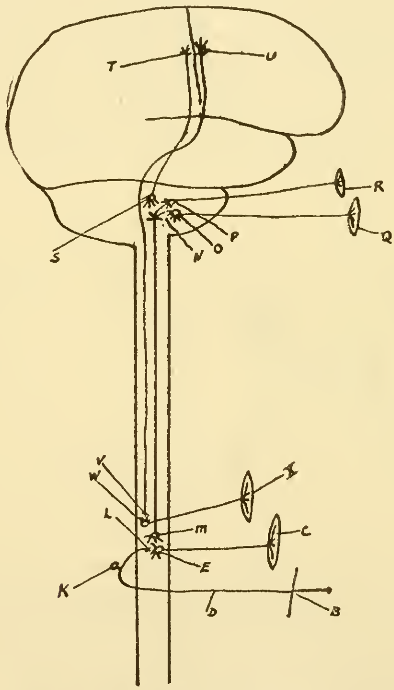

Plate XXXI. Diagrams illustrating in outline form three responses resulting from stimulating the skin by picking it with a pin(at B). In the first case the current flows from B to C by way of D, L, and E, and the hand is jerked away. In the second case the current flows from B to Q and R by way of D, L, M, N, O, and Q or D, L, M, N, P, and R and the eyes are focused on the hurt spot. In the third case the current flows from B to X by way of D, L, M, N, S, T, U, V, and W resulting in a conscious movement of the left hand moved over to rub the hurt spot.

The Intermediate Level. In the illustration in Plate XXXI part of the current which started at B and flowed to L jumps the gap to M instead of to E. It then flows up the spinal cord as far as the base of the brain (to the mid-brain). Here part of this current jumps the gap from N to O and part to P (actually to other points too). From O the current flows to a muscle (Q) which helps turn the head and from P it flows to a muscle (R) which helps turn the eye. With the help of many such muscles the eye is focused on the hurt spot. In this case, as in the first one, we have the response without any consciousness at all. Altho the spinal cord is involved in this action, the connecting of the sense-organ with muscles is in the mid-brain, not in the spinal cord.

The Cortical Level. In the third process, part of the current which came up the spinal cord from M to N jumped the gap to S and went on up to the cortex of the brain. Here it jumped the gap from T to U and then started down through the brain to the spinal cord and then down the cord until it came to V. Here it jumped another gap to W and then flowed out over this nerve pathway to muscle (X) and other muscles not represented. They contracted and the left arm, let us say, reached over and rubbed the hurt hand. Now this third process is essentially like the other two in the general description of the nervous action, except in this last case the current flowed for a part of the way thru the cortex of the brain. When it does that we are apparently conscious of the process. Due to this third process we know that our hand hurts. No one has ever given a satisfactory explanation as to how or why consciousness is aroused when nerve cells in the cortex are involved but the fact remains that this is so. Possibly this analogy may help us grasp the general idea, but it is only an analogy after all. Electric current flowing from the dynamo over wires in the street and into our houses does not give off light, but it does give off light when it flows over the tungsten filament in our incandescent lights. In like manner, apparently, it is only when nervous current passes over nerve cells in the cortex of the brain that it arouses consciousness (comparable to light in the analogy).

SUMMARY.

We have now traced in a rough way how a situation such as "a pin stuck into the arm" is connected with three separate responses, "jerking the arm away," "focusing the eye on the hurt spot," and "rubbing the spot with the other hand."

The elements involved are (1) sense-organs (the mechanisms which receive stimulations), (2) muscles (the mechanisms by which responses are made), and (3) nerve-cells which connect the two together.

Nerve-cells (or neurones, as they are more often termed) may be classified as (1) sensory neurones (which connect a sense-organ to the spinal cord or mid-brain), (2) motor neurones (which connect the spinal cord or mid-brain to a muscle), and (3) connecting neurones (which connect all parts of the spinal cord, mid-brain and brain together).

Depending on the point of connection between the current flowing in from the sense-organ and flowing out toward the muscle we speak of (1) the spinal level, (2) the intermediate, or mid-brain, level, or (3) the cortical (cortex of the brain) level.

Let us keep constantly in mind this whole process as depicted in Plate XXXI and the above paragraphs so that as we proceed to study the separate parts we may come to understand them more and more thoroughly and to link them up with the whole process.

LESSON 35—MECHANISM BY WHICH SITUATIONS STIMULATE US.

"Situations" can effect us only by means of sense-organs. It is impossible to imagine a situation which has neither feeling, warmth, cold, nor painful quality, and cannot be seen, heard, smelt or tasted. A wireless message going thru the air is such a phenomenon but it is not a situation as it does not affect us at all. The wireless operator is affected, of course, by his receiving instrument, an apparatus which transforms the unseen and unheard vibrations into a series of clicks which reach his ear.

Popularly speaking we have five senses—sight, hearing, taste, smell, and touch. Actually we have many more than these, as we shall see. Thru these sense-organs we receive all our information of the outside world. The purpose of this section is to make clear just how the process by which situations stimulate us takes place.

(During this laboratory hour, read over the discussion which precedes each set of instructions and then perform the experiments. Be sure you understand the point of each before passing to the next. If you do not finish during the laboratory hour, you can do the remainder at home as no particular apparatus is necessary).

CUTANEOUS SENSATIONS.

Touch is not a simple sensation but is made up of four kinds of sensations—touch, pain, warmth, and cold. The word *sensation* refers to the simplest sort of conscious response which is possible as the result of a sense-organ being stimulated. As one explores his skin with the point of a knife-blade or toothpick he is conscious of touch, of pain,

and of cold. If the knife-blade were warmed slightly, he would also from time to time be conscious of warmth. And after he had marked the spots on the skin with different colored inks where these different sensations were obtained, he would realize that warmth, or cold, or touch, or even pain can only be obtained when certain points on the skin are touched. At first thought it is rather startling to think that one's skin can be touched in certain places and one will not be conscious of it. But this is true. Evidently there are four different kinds of spots; each arousing a different sensation, and besides there are places in between where no sensation is aroused as a result of slight pressure on the skin.

Apparatus. A toothpick, pin, two large nails; black, red, green, and purple ink.

Procedure. 1. Mark off with black ink a ½-inch square, on the under surface of S's arm 2-3 of the way from the wrist to the elbow. Remove all hairs. Now explore this area with a toothpick touching the skin very gently so that the skin just gives under the pressure of the toothpick and record each point at which S (who is blindfolded) reports he feels the toothpick. Do not drag the toothpick over the skin. Record the points by making a tiny black ink spot on the skin wherever you find a touch spot.

2. Re-explore the area using a pin to discover pain-spots. The pressure of the pin should be only slightly greater than with the toothpick. S should now report not touch-spots but only those spots where slight pain is felt. Record these spots by making a tiny red spot on the skin.

3. Explore this area in the same way for cold spots. The point of a lead pencil or of any piece of metal, as a nail, will serve very well for this purpose. In this case the point may be dragged along the skin. Use green ink to record your cold spots.

4. Explore this area in the same way for warm spots. Use a warmed nail furnished by the instructor for exploring the skin. Use purple ink to record your warm spots. (A nail protruding slightly from the cork of a bottle containing hot water does very well for this purpose. The bottles can be kept immersed in hot water until needed.)

Results. Satisfy yourself that you have the correct answers to the following questions:

1. Do you get different sensations when you stimulate the skin with a toothpick, a pin, a cold nail and a warm nail?

2. Are there distinct points on the skin which always give the same response, if they give any at all, or can you get different responses from the same point on the skin?

3. Will the toothpick arouse any other sensation than touch; the pin, then pain; the nail, than cold; the warmed nail, than warmth?

4. Which of the four kinds of spots are most numerous; which least numerous?

5. Is it possible to touch the skin with a toothpick and obtain no response? Are there points on the skin where the pin can be applied to the skin and not give pain sensation? How about the application of cold and warm nails?

6. What relationship exists between touch-spots and the position of hairs on the arm?

KINAESTHETIC SENSATIONS.

Kinaesthetic sensations are very similar to touch and pain sensations from the skin. They are to be distinguished from the latter in that the cutaneous sense-organs are located very near the surface of the skin, whereas the kinaesthetic sense-organs are located within the muscles of the body and about the tendons which connect the muscles with the skeleton. These kinaesthetic sense-organs are somewhat similar in structure to the touch sense-organs of the skin. They are obviously not aroused by external objects striking them as are cutaneous sense-organs, but they are stimulated by the changes in pressure of the surrounding tissues upon them. When the arm is doubled up certain muscles have contracted to accomplish this motion, certain other muscles have at the same time relaxed. Consequently the kinaesthetic sense-organs located in the first set of muscles have been more or less squeezed while the sense-organs in the second set of muscles have not been pressed upon as usual. At the same time the sense-organs about the tendons have been stimulated in a corresponding manner. These changes in stimulation are reported to the brain and thru experience are interpreted to mean that the arm is doubled up.

All of our information, as to where our arms and legs and fingers are, is reported to the brain in this way, barring, of course, such additional information on this subject as is reported thru the eye or skin. "Movements of the body," "weight," and "resistance to movement" are very complex sensations due to the brain receiving stimulations of varying intensities from thousands of sense-organs scattered thru the muscles and about the tendons. It is then thru kinaesthetic sensations that we get our basic notion of such physical terms as, "motion," "energy" and "mass."

Apparatus. Simple objects at hand.

Procedure. 1. Endeavor to lift the table by placing one after another of the four fingers under the edge of the table and lifting up. Determine where the sense-organs are located which are affected by this

upward pressure, and which give you some appreciation of the weight of the table.

2. Shut your eyes and turn the head slowly about from right to left. Determine where you obtain part at least of the stimulations which tell you the position of your head at each moment.

3. Shut your eyes and rest your arm on the table in as relaxed a position as possible. Let your partner move your fingers about while you determine as well as you can how you know where each finger is. Cutaneous stimulations are, of course, present, so include them in your discussion. But determine what else is present.

4. Shut your eyes and extend your arms before you palms up. Let your partner place two books or similar objects upon your hands. Determine how you distinguish which is heavier.

5. Extend your left arm before you while blindfolded. Then touch a point on the left hand with your right forefinger as designated by your partner. Determine how you know where your left hand is and how you guide the right hand to it.

6. Write your name as usual; then with your eyes closed. To what extent is the writing of your name determined by (a) cutaneous and kinaesthetic sensations and (b) visual sensations?

7. Close your eyes; have your partner hold your hand and so move it about that you write some short phrase. Can you tell what was written by your own hand? In what respect is this situation different from that of ordinary writing?

ASSIGNMENT FOR NEXT CLASS-HOUR.

Read over the remainder of this section and then write out the answers to the above questions.

CUTANEOUS SENSE-ORGANS.

From physiology we learn that located just beneath the skin there are a number of different kinds of nerve-endings. We do not yet know all that we should like to about these nerve-endings, but it does appear with a fair degree of certainty that there is a different one for each of the four sensations of touch, pain, warmth, and cold. And, moreover, that a nerve-ending which gives us the sensation of cold never gives us any other sensation but cold. The same applies to the other nerve-endings. *Each sense-organ gives us a characteristic sensation and never any other sensation but this characteristic one.* This fact is important and should be especially noted. But, on the other hand, *many different kinds of stimulations or situations can produce the same sensation.* A cold spot for example will produce a sensation of cold: (1) when a cold object touches it, (2) when a hot object touches it (but not when a warm object touches it), (3) when an object presses

on it (pressure), (4) when it receives a slight electric shock, or (5) when certain chemicals, as menthol, stimulate it. In the same way a pain spot is aroused and gives us the sensation of pain when: (1) it is lightly touched, (2) it is affected by extreme cold, (3) it is affected by heat (4) it is pressed upon, and (5) it is stimulated by electricity.

These sense-spots are distributed unevenly over the surface of the body, being more frequent on the palms of the hands and on the lips than other places and being very infrequent on the back. The total number of the various sense-organs also varies exceedingly. They appear in the approximate ratio of 1 warm spot, 10 cold spots, 10 touch spots, and 40 pain spots. There are certain portions of the body which are lacking in one or more of these sense-organs. The cornea of the eye lacks warm spots and parts of the cornea lack also cold spots. It has pain spots but no touch spots. A portion of the inner membrane of the cheek is sensitive to touch but not to pain.

SIMPLE AND COMPOUND SENSATIONS.

Besides these four elemental sensations there are various compound sensations, such as: heat, burning sensation, hardness, softness, wetness, dryness, sharpness, smoothness, roughness, itching, tickling, creepy sensations, blushing, etc. All of these are made up of certain combinations of the four elemental sensations or of smaller sensations located in the muscles. For example: heat is a fusion of warmth and cold; burning sensation of warmth and pain; itching is mainly composed of pain sensations, as is tickling of touch sensations. The latter can be aroused by brushing the hairs of the skin. (At the base of each hair is located a touch-spot.) Creepy sensations are a complex, probably, of pain and cold.

Nature's thermometer illustrates this matter of compound sensations very nicely. We do not naturally think in terms of degrees of heat, but rather in terms of pain, burning hot, hot, lukewarm, no particular temperature, cool, cold, biting cold. These various compounds are due to different degrees (intensity) of stimulation of certain sense-organs and to the various combinations of sense-organs which are stimulated. Temperatures of about 86° Fahrenheit (82° to 93° according to the temperature to which the body has been adjusted) arouse no sensations of temperature. Increasing the temperature from 86° we first have the warm spots stimulated, with the resulting sensation (response) of lukewarmness. The higher the temperature the more the warm spots are stimulated, and the greater is the sensation of lukewarmness. At 113° cold spots are also stimulated and the resulting fusion of warm and cold sensations is heat. Above 122° we have in addition to the stimulations of warm and cold sense-organs stimulation of pain sense-

organs. The fusion of all three gives us the sensations of burning hot. In much the same way as we progress from 86° downward in temperature we get cool sensations and these cold sensations due to cold spots being more and more stimulated until 54° is reached. At this point pain sense-organs are stimulated. The fusion of cold and pain sense-organs give us biting cold and finally pain. Thus our terms, "biting cold," "heat," and "burning hot," tho apparently as simple as "cold," and "warm," are nevertheless fusions or compounds of these two simpler sensations together with "pain."

Simple Sensations are not Learned. As soon as the entire nervous mechanism is in working order after birth, a stimulation of any of these four sense-organs will produce its characteristic sensation. In other words, we do not need to learn that a stimulation of a cold spot has the sensation (response) cold. We are born with a bond connecting such a situation with its response. Such sensations are comparable to reflexes.

Compound Sensations are Learned. We do need to learn, however, that acute touch occurring over an extremely narrow surface means sharpness (as with a razor-blade) or that when the finger is moved with no jars and only touch-sensations result that that means smoothness. The compound sensations are learned while the simple sensations are not (i. e., are innate). During the early months of life a baby is engaged very largely in learning what various combinations of touch, visual, auditory, etc., sensations mean, i. e., what objects arouse these combination, or to put it the other way round, what objects really are, as explained in terms of the unlearned responses (simple sensations) which he has at his disposal. Review in this connection the description of the process by which a baby's perception of a rattle develops, as given in Lesson 19.

In the early months of life we learn thru trial and error that a rattle requires so much effort to pick up and that the fingers will close about it in a certain way. A doll, on the other hand, will require more effort and the hand will close about it in a different way. With his eyes shut a year-old baby will know a rattle from a doll which his hand touches, in terms of differences in the number, location, and intensity of the kinæsthetic sense-organs which are stimulated and also in the number, location and intensity of the cutaneous sense-organs which are stimulated. It is extremely difficult for an adult to appreciate this fact because these fusions are developed very early in life and become so automatic as very seldom to arouse our interest in them as such. We gain a little notion of their action when we attempt to become experts in distinguishing textiles

by their feeling, or in estimating weights as to whether a letter needs more than two cents postage, etc.

In the case of judging textiles we develop certain concepts which we use in this work, such concepts being the fusion of certain groups of sensations. An expert in textiles will tell you when you inquire as to how they know one material from another that it is by the "look and feel." Thru practice they have built up certain combinations of touch and visual and even auditory sensations which mean a certain material. If you press an expert as to how they make these judgments they usually cannot tell. They are not aware of the separate sensations which make up the total combination. A few experts can give somewhat of an explanation. Mrs. Blanche E. Hyde says that she tells wool by its "bite" and silk by its "scroop." The sheep's hair from which wool is made is not a smooth hair but has little sharp points which catch on the skin when handled, as any one knows who has worn a flannel shirt. This is for Mrs. Hyde one of the sensations which makes up the total "look and feel" of wool. But it is clear that it is only one, since she is able to detect wool as it appears in many combinations with other materials and manufactured in many ways. The "scroop" of silk is apparently a combination of a certain touch with a peculiar rustling noise occasioned when two pieces of the silk are rubbed together between the thumb and finger. But to the writer other materials which are not silk seemingly give forth a "scroop" when rubbed,—materials which are instantly named by Mrs. Hyde.

The "feel," as we say, for location of keys on a typewriter or piano, or of position on a violin, is no more than a realization of particular combinations of cutaneous and kinæsthetic sensations. We don't know the individual sensations that make up the compound but we do know the compound itself, as is shown by the quickness with which we notice a false move.

All of our motor habits are developed principally in terms of kinæsthetic sensations, altho sensations from other sense-organs play a more or less important part. For example, in lacing one's shoes, the first movement arouses a great number of kinæsthetic, cutaneous and visual sensations. This compound then makes up the situation which starts the next movement going. The second movement in turn arouses a new lot of kinæsthetic, cutaneous and visual sensations. They in turn form the situation which initiates the third movement, etc. Just what part the visual sensations play in handwriting as distinguished from the kinæsthetic can be readily seen by writing with the eyes open and then with them shut. As there is no way of shutting off the

kinæsthetic sensations except by cutting the nerves connecting the kinæsthetic sense-organs with the brain we cannot tell how well we could write if we had only visual sensations to guide us. From certain types of nervous disorders, however, it is clear that we would be fearfully handicapped by such a loss and that our best efforts would fall far short of what we now do. Possibly the best way to realize this is to have some one hold your hand at the blackboard while you are blindfolded and guide your hand so as to write various sentences. Here a new lot of kinæsthetic sensations are aroused and it is surprising how difficult it is to judge what one's own hand has written.

Skill in the use of tools is pretty largely a matter of developing groups of compound sensations composed of cutaneous, kinæsthetic visual and often auditory sensations. As ordinarily we are not aware of the elements, learning to use a plane comes under our type 3b of Lesson 9—learning where the necessary bonds do not exist and where, due to the number and complexity of the elements which must be fused, we cannot calculate the order of succession of the separate movements. Consequently, we can only learn to use a plane when working with it. The more, however, our instructor explains the plane and corrects our faulty moves, the more are we made conscious of the details involved in the whole process and of the necessary sequence, and the quicker we learn.

WHAT IS A "SITUATION?"

The term "situation" has meant so far "the sum total of all factors which bring about a response." This is a good psychological definition of it. But in order to have a clearer notion, it is well to realize that "the sum total of all factors" may be divided into two parts. These are:—(1) an outside factor which is stimulating a sense-organ and (2) a sense-organ that is stimulated and that causes a nervous current to flow toward a nerve-center. To make the distinction clearer consider the example of jerking our hand from a hot stove. There is first of all the outside factor of the hot stove in contact with our skin, and there is second the inner factor of a sense-organ in the skin which responds to this stimulation and further arouses a nervous current which causes the muscles to contract and jerk the hand away. If the skin were anæsthetized or if the nerve were cut no action would follow, even if the hot stove were there.

When we think of "situations" we must consider (1) what effect they have upon the sense-organs of an individual; but much more must we consider (2) the effect within the individual which will result—an effect based upon the individual's instinctive equipment plus all of his experiences (habits) in life.

If a situation arouses the sense-organ the response which follows is the response which the sense-organ produces. In other words, the organism can bring about only those responses which outside situations initiate, but what the responses are and the general way in which they appear is determined by the inherent nature of the organism itself. An appreciation of this fact is only just beginning to dawn upon the world in general. Its application is leading to a more profound knowledge of how to advertise, how to sell, how to handle employees, how to teach, how to handle people in general.

LESSON 36. THE EYE: A MECHANISM BY WHICH SITUATIONS STIMULATE US.*

In the case of the cutaneous and kinæsthetic sense-organs the structure of the sense-organ is relatively simple. There the stimulus affects the nerve ending in a direct manner. The eye, on the other hand, is an elaborate mechanism.

In order to understand this mechanism it is necessary first of all to obtain some idea of the structure of the sense-organ itself and also the physical nature of the stimulus. These points will consequently be considered and then several other factors of a general nature will be presented dealing with normal and defective eye sight.

STRUCTURE OF THE EYE.

The eye can be best understood if it is compared to a camera. The three parts essential to a camera are the box, the lens, and the film. Let us consider the structure of the eye with these three divisions before us.

The gross structure of the eye (the box). "The eye has a tough, thick outer coat, the *sclerotic*, to which are attached the muscles that move it" about in its socket. "Inside the sclerotic is another membrane, the *choroid*, which contains blood vessels and is provided with a dense dark pigment that renders the inside of the eye essentially impervious to all light, save that which comes thru the opening in the *iris*." Inside the choroid is the third layer, the *retina*, which will be discussed later. Note the relationship of these parts in Plate XXXII.

The lens system is made up of two parts—the cornea and the crystalline lens. The *cornea* is really only a part of the sclerotic coat. But the structure of the tissue is changed somewhat from the remainder of the sclerotic layer—being transparent instead of being white and opaque. The lens lies just behind the iris, the colored portion of the eye. It is attached to the choroid coat by a ligament, which is in turn attached to the *ciliary muscle*. Between the cornea and the lens we have a small chamber filled with a liquid much like water (aqueous humour). Back of the lens we have another chamber, occupying the interior of the eye. This chamber is filled with a jelly-like substance (called the vitreous humour).

The *retina* (the film). As already pointed out, the retina is the inner membrane of the eye. It is really a part of the brain, being composed of nerve-cells which in the course of development have

*CLASS-HOUR	IN CLASS	WRITE UP	READ
36	Discuss, 34, 35		Lesson 36
37	Experiment, 37	Lesson 37	
38	Discuss, 36, 37		

come to the surface. It is made up essentially of three layers of these nerve-cells, the inner layer being composed of what are known as *rods* and *cones*. (According to Kölliker the cones in the fovea are from 0.0045 mm. to 0.0055 mm. in diameter, i. e., 0.000177 inches to 0.0002165 inches. This gives some idea of their minuteness.)*

Directly opposite the iris and the center of the lens is the *fovea*. This is a point in the retina where there are only cones. It is the point of clearest vision—the part of the eye which receives the greatest number of stimulations. This is true, since whenever we are looking directly at an object the head and eyes have been so turned that the light waves fall upon this spot. Leading back from the nerve-cells in

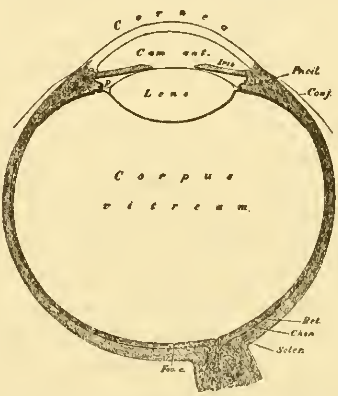

Plate XXXII. Opt., optic nerve; Fov. c., fovea centralis; Scler., sclerotic; Chor., choroid; Ret., retina; Conj., conjunctiva; Pr. cil., ciliary processes by means of which lens is adjusted; Cam. ant., anterior chamber filled with aqueous humour; p. posterior chamber. Just below "p" the capsule and ligament supporting the lens are shown attached to the ciliary processes. Corpus vitreum, the vitreous humour of the main cavity of the eyeball. (From J. R. Angell, Psychology, 1909, Figure 47, published by Henry Holt and Company.)

the retina are nerve-fibres which unite and form the optic nerve which proceeds first to the mid-brain and then on to the cerebrum. The rods and cones have apparently different functions. Color is perceived because of the stimulation of the cones, while light and darkness are perceived because of the rods. Especially is this function of the rods true as regards vision in dim light. Color blindness is due to an affection of the cones, while faulty vision in dim light is due to that of the rods.

THE NATURE OF THE LIGHT STIMULUS.

In both visual and auditory sensations we must distinguish three different stages in the sensory excitation. There are first, the physical

*Ladd and Woodworth, op. cit., 316.

stimulus, second, a physiological change in the sense-organ, and third, the resulting conscious quality.

The *visual physical stimulus* is due, so physics teaches us, to vibration in the ether, whereas the auditory physical stimulus is due to vibration in the air. Such vibrations may vary in three ways: in the rate of vibration, in the amplitude of the vibration, or in the form of the wave.*

(1) Changes in the rate of vibration. The ether may vibrate more slowly or more rapidly. When it vibrates at the rate of 390,000,000,000,000 per second we become conscious of the color red. When it vibrates at twice this rate (i. e., 757,000,000,000,000 per second) we become conscious of violet. The other colors fall in between these two extremes. Beyond these two extremes are other vibration rates which are known to physics but which do not stimulate the retina. Ultra-violet rays do not affect the human camera but they do affect the film of a kodak. Other such rays invisible to man are the X-rays, and the rays by which wireless messages are sent. Changes in the rate of vibration within certain limits are responsible then for the particular colors that are consciously seen.

(2) Changes in the amplitude of the vibration result in differences in the intensity of the colors, i. e., in the brightness of the color. Amplitude refers to the amount of back and forth swing to the vibration. If one strikes a tuning fork it gives forth a loud tone at the start when the prongs are swinging back and forth vigorously and as this movement dies down the tone becomes weaker and weaker. Here there is a change in the amplitude as the vibration dies down but no change in the rate of vibration. Suppose in the case of light we have 390,000,000,000,000 vibrations per second striking the retina, giving us the sensation red. Now if the amplitude was practically zero, i. e., there was practically no back and forth swing, this red would appear practically black. As the amplitude was increased one would have successively, brown, dark red, red, bright red, pink, and with a very great amplitude, white. Changes in the amplitude, then, determine the amount of white or gray or black that is seen either alone or in combination with a color.

(3) Changes in the form of the wave. The ether may be vibrating so as to produce pure red or pure blue or it may be vibrating so as to

*Those unfamiliar with these terms will do well to experiment with a guy-wire supporting a telephone pole, which is attached at the top of the pole and to an anchor in the ground. Or a stout string tautly stretched from one end of the room to the other will serve the purpose. Strike the wire with a stick or the string with a pencil and note the wave that runs along them. The wire itself does not move forward but it so vibrates that a wave does travel and if one will take hold of the far end of the wire or string he will note that considerable force is exerted by the wire against its end support. In these examples the rate of vibration depends upon the material, length, etc., of the wire. The amplitude (size of the wave) depends upon how hard it is hit. The form of the wave depends upon whether it is hit once or twice in very quick succession, etc.

produce red and blue at the same moment. In this case we are not conscious of red and blue separately but instead of the color purple. White light from the sun is a case where the ether is vibrating to give us all the colors simultaneously. With the use of a prism these various vibrations can be separated and then we get all of the colors instead of their blending, which appears to us as white.

Change from the physical stimulus to physiological process. The physical stimulus—the vibrating ether—having travelled from the object outside to the retina affects the rods and cones in some way still unknown. A number of theories have been advanced but no one has been accepted by all. All that we do know is that here a radical change takes place in the form of the light stimulus, for the ether vibrations now set up certain physiological or chemical changes in the rods and cones. This chemical action is then transmitted along the nerve-fibres to the mid-brain and then on to the cortex of the brain. Possibly the best analogy to explain the transmission of this chemical change is to picture a train of gunpowder along a sidewalk. When a burning match is applied at one end the combustion is almost instantaneously transmitted to the other end. Combustion is, of course, a simple chemical change, so that the spread of the fire is an instance of spread of chemical change. Recent experiments prove that CO_2 is given off by nerve-fibres when engaged in transmitting stimulations, indicating the presence of chemical changes in the fibre. Then, too, the fact that the nervous impulse travels comparatively slowly, i. e., 100 feet per second suggests a chemical process. This is very slow as compared with the speed of sound which is 1,100 feet per second, or of light with a speed of 180,000 miles per second. Electricity in a good conductor will go about as fast as light. About all, then, that we can say is that the physical stimulus is changed into a physiological one when the light waves strike the retina. And from here the stimulus is conveyed over several nerve-cells to the optic nerve and over this pathway to the mid-brain and from there finally to the cortex of the brain.

The change from physiological process to conscious quality. In the cortex of the brain this stimulus which has traversed the optic nerve gives rise to the conscious qualities of brightness (black-gray-white) and color with which we are all familiar. But here again we know nothing as to how the nervous changes in the nerve-cells produce the qualities of which we are conscious.

How we see the North Star. Because of the molten state of the North Star it causes the ether to be set into vibration. This vibration-wave is very complex so that when its light-wave is broken up by

passing it thru a prism we can obtain many different colors. Altho light travels at the incredible rate of 186,000 miles per second, astronomers figure it takes 44.0 years for the vibration to reach the eye. It passes thru the cornea, the aqueous humor, the lens, the vitreous humour, and the two outer layers of the retina and finally reaches the rods and cones. Here it arouses a physiological process (thru chemcal changes, possibly somewhat similar to the change produced in a kodak film). This process is transmitted to the brain and there interpreted in terms of a spot of light in the dark sky.

CONVERGENCE, DIVERGENCE AND ACCOMMODATION.

By means of six muscles attached to each eye, the eye balls may be turned in their sockets so that the rays of light from an object, at which we are looking, may fall upon the fovea. When the two eyes are made to turn inward toward a nearby object the process is called *convergence.* When they are turned outward toward a distant object it is called *divergence.* These little muscles as they relax or contract arouse kinæsthetic stimulations which are scarcely ever noticed in a conscious way. Nevertheless, estimation of distance is based to a very considerable extent upon these stimulations.

Thru the processes of convergence and divergence the two eyes are adjusted so as to be both turned toward the same point. But this is not sufficient to secure clear vision. In a camera we must regulate the distance of the lens from the film according as the object to be photographed is near or far away. In the human eye this adjustment is made not by moving the lens but by changing its shape. This process is called *accommodation.* The ciliary muscle controls the lens causing it to become more or less convex, thus affecting the convergence of the rays of light upon the fovea. In monocular vision differences in distance up to a few feet can be estimated fairly accurately in terms of the kinæsthetic sensations arising from the ciliary muscle. These estimations are, however, unconsciously made.

DEFECTIVE VISION.

Myopia and Hyperopia. In the normal eye the distance from the cornea to the fovea is 20 millimeters (3/4 of an inch). If now the eye is so constructed that this distance is greater than 20 mm. the image of distant objects is formed in front of the retina and only near objects can be clearly seen (near-sightedness or myopia). On the other hand, if this distance is less than 20 mm. then the image of objects will be formed behind the retina and the refractive power of the eye must be increased to permit of clear vision (long-sightedness or hyperopia). "The hyperopic eye must consequently exert an effort of accommoda-

tion in order clearly to see objects at a distance, while for near work this effort must be excessive. The result is that the hyperopic eye is under constant and abnormal strain from the incessant demands upon its ciliary muscle, and that, in consequence, numerous secondary symptoms or resultant effects appear, some of them obvious, others unexpected, many of them serious. Local symptoms appear in inflammation, redness, or soreness of the eyes, lids or conjunctiva, and in twitchings and pain within the eye ball. Aside from these local disturbances, perhaps the most constant symptom of hyperopia is frontal or occipital headache."*

Both myopia and hyperopia may be counteracted by the use of glasses.

Astigmatism. "In a perfectly normal or ideal eye the refractive surfaces, cornea, anterior and posterior surfaces of the lens, are sections of true spheres, and, all the meridians being of equal curvature the refraction along these different meridians is equal. Such an eye will bring the cone of rays proceeding from a luminous point to a focal point on the retina, barring the disturbing influence of chromatic and spherical aberration. If, however, one or all of the refractive surfaces have unequal curvatures along different meridians, then it is obvious that the rays from a luminous point cannot be brought to a focal point, since the rays along the meridian of greater curvature will be brought to a focus first and begin to diverge before the rays along the lesser curvature are focused. Such a condition is designated as astigmatism."†

In a person afflicted with astigmatism there must be a ceaseless activity of the ciliary muscle as first one point and then another of a scene is focused. In normal vision many of such points can be focused at the same time thereby requiring less effort of this muscle and also providing fuller and richer vision. Astigmatism can ordinarily be corrected by wearing properly fitted glasses.

Color-blindness. About 4% of men and less than 0.5% of women are color-blind. Most of these are red-green blind which means that they do not see any difference between these two colors. "Total color-blindness, while well-authenticated, is rare, and is presumably a pathological defect." "It is obvious that many callings are, or should be, closed to the color-blind, e. g., railroading, marine and naval service, medicine, chemical analysis, painting and decorating, certain branches of botany, microscopy, mineralogy, the handling of dry goods, millinery, etc. In some phases of school work, the color-blind pupil is likewise at an evident disadvantage. The color-blind test should, accordingly, be regularly instituted in the early years of school life, in

*G. M. Whipple, Manual of Mental and Physical Tests, 2nd edition, 1914, p. 164.
†W. H. Howell, A Text-Book of Physiology, 1907, p. 302.

order that the existence of the defect may be made known to the child as soon as possible."*

FUSION OF VISUAL AND TACTUAL SENSATIONS.

Professor Stratton carried on some experiments a number of years ago, as follows. He wore constantly for a week a pair of glasses with two lenses so constructed that every object appeared upside down. "The results showed that an experience coming from such an image would in time be indistinguishable from our normal experience. The first effect was to make things, as seen, appear to be in a totally different place from that in which they were felt. But this discord between visual and tactual positions tended gradually to disappear; not that the visual scene finally turned to the position it had before the inversion, but rather the tactual feeling of things tended to swing into line with the altered sight of them. The observer came more and more to refer his touch impressions to the place where he saw the object to be; so that it was clearly a mere matter of time when a complete agreement of touch and sight would be secured under these unusual conditions." As Stratton points out "harmony of touch and sight can grow up under the greatest variety of circumstances, provided merely that the experience remains uniform long enough to develop fixed expectation.†

Undoubtedly this is exactly what has happened to each of us in infancy. The child is engaged in early life in receiving a maze of sensations and as certain combinations occur over and over they become fused together and finally become thought of as an object. A rattle, for example, is at first a hodgepodge of tactual, kinæsthetic, visual, and auditory sensations. Eventually it is a rattle having all of these various characteristics, and moreover when it is touched in the dark the tactual stimulations bring to mind not only tactual notions of the rattle but also visual, kinaesthetic, and auditory sensations all fused together into the percept of a rattle.

SUMMARY

The eye is merely a mechanism for adjusting physical light vibrations so that they will arouse physiological changes in the retina, which, in turn, will be conveyed to the brain and interpreted in terms of our past experiences. A visual situation must be thought of, not in terms of the object itself, but in terms of the nervous processes which are aroused by it.

ORGANIC. GUSTATORY, OLFACTORY, AUDITORY AND STATIC SENSATIONS

In addition to cutaneous, kinaesthetic and visual sensations, we have

*G. M. Whipple, op. cit., p. 169.
†G. M. Stratton, Experimental Psychology and Culture, 1903, p. 146-149.

several others. Organic sense-organs are similar to cutaneous and kinæsthetic, but are located not in the skin or about the muscles, but in and about the internal organs. From these sense-organs we obtain the little information that we do receive as to the working of these organs. They arouse such sensations as thirst, hunger, nausea, heart-burn, suffocation, pain of a general, massive, agony type, and general bodily feelings of well or ill. Gustatory sense-organs are located in the mouth, and olfactory in the upper portion of the nasal cavity. Sensations of taste and odor are too familiar to need discussion here.

Organic, gustatory and olfactory sensations are similar to cutaneous and kinaesthetic. A specific stimulus affects a very simple sense-organ consisting apparently of not much more than a nerve ending and we obtain the sensation characteristic of that sense-organ.

Auditory situations, on the other hand, are received and affect consciousness by means of an elaborate receiving mechanism similar to the eye in complexity. It is not essential that the anatomy of the ear be mastered. It is sufficient that one realizes that a physical stimulation—vibration of the air—is converted within the ear into a physiological stimulation which is transmitted over the auditory nerve to the brain and that there the air vibration is expressed in consciousness in the form of different tones and noises and their combinations.

Still another type of situation which affects us is known as the "static." We are not directly conscious of it, but only indirectly through its influence upon other sense-organs, particularly the organic sense-organs. Within the semi-circular canals of the ear and two adjacent small bodies are little hairs projecting into the liquid filling these organs. Whenever the head is moved, the liquid is disturbed, just as water in a glass is disturbed if the glass is moved. The liquid in turn disturbs the hairs, which in turn excite the nerves connected with them. These stimulations are transmitted to the mid-brain and from thence to various sense-centers which control the movements of the body. Here is the mechanism, for example, which starts the movement to regain our equilibrium when we slip on a banana peel. Excessive stimulation of these static sense-organs, as in swinging in a swing, whirling around, being tossed about in a ship, etc., brings about changes in the bodily organs. These changes in turn affect the organic sense-organs therein situated and we feel dizzy, or seasick.

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LESSON 37—HOW DOES ONE ESTIMATE DISTANCE?

SPACE-PERCEPTION.

The first few minutes of the laboratory hour will be devoted to a demonstraton of a model of the eye. Be prepared to clear up any difficulties you had in obtaining a general idea of the construction of the eye.

We have seen in Lesson 35 that there are four cutaneous sensations which are simple experiences and cannot be resolved into any simpler sort of consciousness. We have also seen that there are a great many other so-called sensations which appear at first thought to be equally simple, such as hardness, softness, dryness, smoothness, etc. But, on closer study, these can all be resolved into simpler sensations. These so-called sensations have been referred to as compound sensations. Compound sensations have been developed thru experience—have been learned. Another term of somewhat similar meaning is "percept." When we use the expression "compound sensation" we have reference primarily to the abstract quality, say of sharpness; when "percept" is employed we are thinking of the particular object which is sharp. Actually, it is very improbable if we ever experience "sharpness" as a compound sensation in this sense, but rather always think not only of sharpness but also of the object which occasions the sharpness. That is, the combination of elementary sensations gives us directly the perception of a *sharp object.*

But a percept can be and usually is much more complex that a compound sensation. The percept of an apple includes sensations of vision, touch, taste, smell and hearing (sound of crunching a piece of apple) whereas a compound sensation has reference to combinations of sensations from the same sense-organ.

Apparently the estimation of any distance is a perception, due to the combination of certain sensations experienced together and from experience known as "this object" "so far from us." Now we want to discover in this lesson and in Lesson 39 some of the factors in terms of which we perceive that a certain object is nearer than a second object and farther away than a third object. For example, how do you know that the tree you see is outside the window instead

of inside? How do you know this telephone pole is nearer than that one?

This problem is assigned not only because it is worth while in itself, but because it will illustrate to some extent how we have built up thru experience such notions as distance, time, space, height, weight, etc. In fact, the fundamental principles of how we have learned to estimate distance underlie the development of all our perceptions of objects, as a cow, horse, barn, book, etc.

This problem is also assigned because it illustrates the analysis teachers must make of the processes they are to teach. The more detailed a grasp of the separate processes involved in using a plane, or saw, or pen, or typewriter he has, the better can the teacher teach their use. For when the complex whole has been analyzed into its component parts, then the teacher can call the student's attention to the parts and aid him in mastering each part and performing them in their proper sequence. Otherwise the learning must be entirely a "trial and error" performance — the most irritating and inefficient way of learning.

ESTIMATION OF DISTANCE.

The problem before us primarily is the determination of the *relative* distance of one object in reference to other objects, i. e., is it nearer or farther away than some other object? The conversion of this idea of relative distance into measurements of distance, such as stating its distance in feet, is another matter and will not concern us in this experiment.

If we close one eye and move our finger back and forth toward the nose and then away from it, it is clear that we can determine its position with regard to our nose very well. How we do this with one eye (monocular vision) is one problem.

If we look with both eyes at near objects and then objects farther away (but less than 100 feet), it is again clear that we can determine their relative position very well. How we do this with both eyes (binocular vision) is a second problem.

And if we look at distant objects thru the window, it is also clear that we can determine their relative distance, although possibly not so well. How we do this is a third problem.

The second problem of binocular vision under 100 feet distance will be tackled in this lesson; the first and third problems in Lesson 39.

EXPERIMENT

Problem: What are the factors underlying the Perception of Distance of Objects within 100 *feet with Binocular Vision?*

Apparatus: A number of small objects; a stereoscope and views of the Titchener Series.

Procedure:

(1) Select some narrow object (A), as the string attached to the curtain in the window, or the wooden strip between two panes of glass in the window, or a drop cord supporting an electric light. Seat yourself so that you can look past the object to some other object (B) some distance away. Now alternately focus on A and B fifteen to twenty times. Note that A appears first as one string and then as two strings. Note the change in the strain felt in the eyes. And note also changes in the position of your partner's eyeballs when he is thus focusing back and forth.

(2) Select two books (C and D). Stand book C on end upon the table with its side about three feet away (placed at three feet to exaggerate the phenomenon). Stand book D a few inches nearer and with its *back* towards you. Book D now stands more or less perpendicular to book C. Now note the difference in the details which can be seen of book D as you look at it alternately with the right eye and the left eye. Also observe the differences which can be seen in book C under the two conditions—book C acting as a background for the view of book D. (If you do not discover such differences in book C, move your position slightly. But be very careful not to move the head from side to side as you look alternately with one eye and the other.) Note the following points: (a) The two views are different; (b) the points on the back of the book D are displaced more from right to left than the points of book C; (c) the view seen by the two eyes together is a fusion of what both eyes see—not an average of what the two see—and one is not conscious of whether he sees a detail with one eye or with the other (not until he has experimented).

Confirm these points and add any others that are discovered thru studying these and other objects about the room. Draw what is seen with each eye separately when looking at the two books.

(3) Carefully note the differences in the details of the two photographs which comprise a stereoscopic picture (use, for example, Nos. 15, 17, 37, etc., of the Titchener series). Choose two points in the picture, one of which is in the very near foreground and the other far back in the background. Measure carefully the distance from these two points to the right hand edge of the picture in which they occur. Note whether a near-point varies more to the right and left in the two photographs than a distant point.

(4) Note slide No. 1. Here are two views composed of two dots each. In the right hand view, however, the dots are spaced farther

apart than in the left hand view. Why, when seen in the stereoscope, does one dot appear nearer than the other? Would this occur if the spacing between the two dots was the same in the two views?

Results: Carefully compare your findings in the four experiments. What relationship do they bear to one another? Answer the following questions, after reading over the section in Lesson 36 on "Convergence, Divergence and Accommodation":

(1) How do the differences in what is seen by the two eyes of a near object differ from what is seen of a distant object? How do the differences in objects in the foreground of two stereoscopc pictures differ from the differences in objects in the background? Explain.

(2) Is there any relationship between the differences in the view of a book as seen by the two eyes and the differences between two stereoscopic pictures? Explain.

(3) Is it correct to state that when the two views of an object, as recorded on the retina of the two eyes, differ, then those points which differ most are seen as nearby while those points which differ only a little are seen as far away? Explain your point of view.

Application. What general relationship is there between the results discovered here and learning in general?

ASSIGNMENT FOR NEXT CLASS HOUR

1. Write up the above experiment.
2. Be prepared to discuss Lesson 36 in class.
3. During the next few days be gathering data on how you are able to determine the relative distance of objects, both of which are more than 100 feet away. Jot down every clue that comes to mind. (The answers to this problem are very simple, so simple that most students overlook them in endeavoring to discover some profound proposition.)

LESSON 38. THE MECHANISM BY WHICH RESPONSES ARE MADE*

In Lesson 34 a bird's-eye view of the whole physiological explanation of behavior was presented. This was expressed under three general headings: Stimulation of a sense-organ (the situation), movement of a muscle or muscles (the response), and the connection of sense-organ and muscle (the bond). In Lessons 35 and 36 we have studied typical mechanisms by which situations affect us. We have seen that certain kinds of stimulations arouse a sense-organ to activity and that that activity is passed on over nerve pathways to the spinal-cord or brain. We now shall consider how the response is made to these situations.

In order to have before us a proper perspective, consider again the example given in Plate XXX. There is illustrated the simplest possible type of situation and response (reflex action). A pin is stuck into the skin. One or more pain and touch spots are stimulated. A nervous discharge from these sense-organs proceeds over the nervous pathway to the spinal-cord. This current then jumps a gap to another nerve-cell along whose fibre it proceeds until it reaches the muscle C. This muscle then contracts and the arm is pulled away. (Actually, the case is more complex, involving more than one muscle and more than one pathway.) This example illustrates a complete situation-response functioning. The problems before us are: Just how does a stimulated muscle move a portion of the body, and, second, how does a nervous current stimulate the muscle and cause it to react?

HOW DOES THE CONTRACTION OF A MUSCLE MOVE A PART OF THE BODY?

In Plate XXXIII is shown a diagram of the two major muscles of the upper arm and their relation to the bones of the arm, forearm, and shoulder. The biceps ("4" in the diagram) is attached to the shoulder and to the bones of the forearm. In the latter case it is attached a short distance beyond the elbow end of the bone. The bones of the forearm and upper arm are jointed together somewhat after the fashion of a door-hinge. If the biceps should contract, it is clear that it would pull the shoulder blade and the bones of the forearm. Either the shoulder or the forearm bones would have to move. As the shoulder is fastened, the forearm has to swing up. The forearm acts like a lever here.

*CLASS-HOUR	IN CLASS	WRITE UP	READ
38	Discuss, Les. 36, 37		Lesson 38
39	Experi. Les. 39	Lesson 39	
40	Discuss, Les. 38, 39		

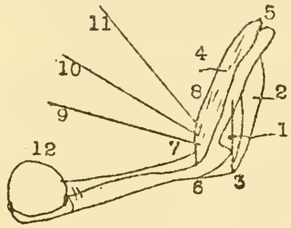

Plate XXXIII. Motor Mechanism. 1. The humerus. 2. The muscle by which the joint is straightened (the triceps). 3. Its insertion. 4. The muscle by which the elbow is bent (the biceps). 5. Its origin. 6. Its insertion. When the muscle 4 contracts by an amount represented by 7 to 8, the amount of motion of the ball will be represented by 9 to 11. There is a loss of power which is compensated by an increase of motion. (D. J. Hill, The Elements of Psychology, 1888, p. 401).

A slight pull on it at 6, where the biceps is attached to it, results in a large movement at the finger ends. In compensation for the increase in motion at 12 over that at 7, there is a corresponding loss in power. Contraction of the biceps results, then, in movement of the forearm.

Muscles which have to do with movements of the body are attached to the bones of the body. They are normally in a state of elastic tension. In most cases, they are in pairs, as in the case of the forearm. One pulls the arm up, the other down. The elastic tension is conducive to a smooth and very prompt movement. When the biceps is stimulated so as to contract, the triceps are stimulated so as to relax, and vice versa.

HOW DOES THE NERVOUS CURRENT STIMULATE THE MUSCLE AND CAUSE IT TO REACT?

Before answering this question, a few facts need to be considered concerning the structure of the muscle. There are two kinds of muscles: (1) Striated skeletal muscle, and (2) plain muscle. Muscles which move the body belong to the first group, while muscles which have to do with the blood vessels, alimentary canal, glands of the body, etc., belong to the second group. We shall consider here only the former group. A skeletal muscle is made up of many fibers composed of a single cell, enclosed in an elastic membrane. When the motor nerve enters the muscle, it subdivides and subdivides until there is at least one nerve fibril attaching itself to each fibre of the muscle. The point of attachment is near the middle of the fibre. This point is called a motor end-plate. Returning to our main question now, we can see that when a nervous stimulation is transmitted from the spinal cord to the muscle it reaches, by way of these motor end-plates, every fibre in the muscle. The effect of this stimu-

lation on the muscle is to produce a chemical change (as yet not very well understood) which causes the fibre to contract. Consequently, the whole muscle contracts, and its attached bone is moved.

When a muscle contracts, it gives off heat and electrical energy and produces work. In other words, the chemical change caused by the stimulation of the muscle can be likened to the case of a gas-engine, where heat and work result from the combustion of gasoline. But the human muscle is a very much more efficient engine than a steam or gasoline engine. Only 10 to 15 per cent. of the energy contained in coal is converted into work by a steam engine, 15 to 25 per cent. of the energy in gasoline in the case of a gasoline engine, whereas from 25 to even 40 per cent. is utilized in the case of a muscle. The remainder of the stored-up energy is wasted mainly in the form of heat. In the case of an engine, this is all pure waste, but in the case of the animal, much of this heat is utilized in keeping the organism warm.

FATIGUE

The contraction of the muscle is due to chemical changes. As a result of these changes, carbon dioxide gas (CO_2), lactic acid ($C_3H_6O_3$), and acid potassium phosphate (KH_2PO_4) are liberated. Glycogen, the form in which digested sugar is stored in the body, disappears. *Fatigue,* which is due to excessive contractions of muscles, is chemically the loss of glycogen and the abnormal presence of these by-products. As a steam engine will cease to run when the coal is exhausted or when the grates are choked with ashes, so a muscle becomes fatigued when the glycogen is used up or the muscle is poisoned by the waste products of its combustion.

Whether work is fatiguing or not depends largely upon whether the blood can supply glycogen fast enough to supply the working muscle and at the same time remove the waste products. The faster the muscles are operating, the greater the load upon the heart, lungs and blood, and the quicker fatigue will appear. Recently, experiments have demonstrated that the establishment of short *rest periods* thruout the working hours tends to lessen fatigue and so permit of a greater amount of work being done. The wheelbarrow men, mentioned in Lesson 1, who could do more work by working twelve minutes and resting three minutes in every fifteen minutes, instead of working steadily all day, illustrated this fact. The principle is now well recognized in industry and is being utilized by many firms.

As so-called mental work seldom calls for a steady, rapid use of any set of muscles, the rest-period principle hardly applies to it as it does to hard physical labor. A recess period every hour or two is probably

all that is necessary to rest the large muscles which are engaged in supporting the body while one is reading or writing. Experimental studies of fatigue from mental work show that the amount of fatigue is very small. For example, "Heck* gave tests to school children at four periods during the day — between 9 A. M. and 9.30 A. M., between 11 A. M. and 11:30 A. M., shortly after 1 P. M., and about 2.30 P. M. It appears from this experiment that the amount of work done is increased in the later periods, while the accuracy decreased, but there does not appear to be any large decrease in efficiency due to fatigue."** Table XV shows typical results from one school.

TABLE XIV. SHOWING ARRANGEMENT OF EIGHT CHILDREN ACCORDING TO THEIR INNATE ABILITY IN ADDITION (B-TEST) AND MULTIPLICATION (BX-TEST) AND THE TWO SETS TAKEN TOGETHER

	PERIODS			
	9.00 A. M.	11.00 A. M.	1.30 P. M.	2.30 P. M.
Amount done	100	100.72	103.63	101.10
Accuracy	100	96.69	95.64	96.38

The real problem in the school-room is not fatigue, but ennui, lack of interest. As Thorndike has repeatedly affirmed, children have too little to do rather than too much. They are not supplied with material to keep their minds and bodies busy. Any adult who has attempted to play with children knows how impossible it is to tire them out. They can keep on the jump from morning to night, or build blocks, or paste in a scrap book as assiduously as any adult, when they want to.

EXHAUSTION

Fatigue is a perfectly normal process. It may be defined, according to Thorndike, as "that diminution in efficiency which rest will cure."† *Exhaustion*, on the other hand, is a loss of efficiency which ordinary rest will not cure. In cases of exhaustion, not only is the glycogen used up, but also part of the muscular structure itself. In consequence, it takes a comparatively long time for one to recover from the effects of exhausting work.

Exhaustion is present in the case of many persons who are forced by circumstances to work harder and for longer hours than they can really stand. Its elimination is an important industrial and social

*W. H. Heck. A Study of Mental Fatigue in Relation to the Daily School Program. Psylchological Clinic, Vol. 7, 1913-14, pp. 29-34 and 258-260.

**Quotations and Table XV from F. N. Freeman, How Children Learn, 1917, p. 289.

†E. L. Thorndike, Educational Psychology, Vol. III, 1914, p. 112.

problem. But fear of exhaustion, on the other hand, does still more harm, for it prevents men and women from exerting themselves as they should and robs them of the success they might otherwise achieve. Aside from worry, a most fatiguing performance, very few of those directing their own activities ever exhaust themselves. It is normal to go to bed fatigued. Sufficient sleep should cure fatigue and fit us for another strenuous day. Happy is the man, like Roosevelt, who finds his greatest pleasure in activity.

WHAT IS A RESPONSE?

The term "response" has meant so far all those details of an individual's action which result from some situation affecting him It is well now to consider the term in greater detail. A response consists of movements of muscles. But the muscles may be those that (a) move parts of the body, as the arm, leg, head, etc., or (b) affect the internal organs, as the heart, the stomach, the various glands, etc. The first type we are all more or less familiar with, since we are continually and consciously making such movements and are observing them in others. The second type we are not conscious of ordinarily. But they play an equally important part in our life. In the quotation in Lesson 1 from "Wednesday Madness," we read "Sam started violently" in response to Penrod's "Sam-my and May-bul." And "Mabel ceased to swing her foot, and both, encarnadined, looked up." The "starting violently" and becoming "encarnadined" are evidences we may note in another of emotional excitement — a term covering movements of the inner organs. And these responses are more significant in this case than "ceasing to swing her foot" and "looking up."

It is related that if a cat is quietly eating her dinner under a table and sees a strange dog enter the room, that she will cease eating, her fur will stand on end, her tail will rise erect, she will crouch and assume the best possible position to flee or fight according to circumstances. This is all we can see as to her response to the dog's presence. But careful studies have shown that even if the dog leaves the room without seeing her and she returns to eating that her digestive organs will not resume their activity for 15 to 20 minutes. The response to the dog's presence on the part of the inner musculature was to increase the heart's action, to expand the breathing area of the lungs, to constrict the blood vessels in the viscera and dilate those in the muscles, thus driving the blood into circulation between heart, lungs and muscles, to affect certain glands which give off chemicals, further increasing the above effects and even affecting the blood so if the cat is wounded the blood will coagulate more quickly, etc. And these effects do not immediately cease when the situation changes.

The above illustrates what takes place under the general heading of *emotion.* Human beings are affected in a similar manner. And, apparently, all emotions affect us in much the same way, whether they be of fear or joy, of love or hate.

In selling, for example, it is as important to realize that the prospective buyer will react to the sales talk by tones of voice, expression of the face and movements, as by words of mouth. And such responses, when properly interpreted by the salesman, are more helpful in determining what his prospect is really thinking than what he says. For the buyer can hardly control movements showing eagerness or irritation, although he may restrain any spoken indication of his attitude.

A response may consist, further, in a train of thought, in the formulation of a decision, or in an attitude. The latter we saw clearly in the mirror-drawing experiment, where some assumed a self-attentive attitude and others did not. But such purely "mental" responses are accompanied by muscular movements, although they may at times be very slight or seemingly of no connection with the mental processes. One only has to watch carefully a person who pretends to be contemptuous of one's teasing to discover slight twitchings at the corner of the mouth, or tapping with the foot, etc.—all signs that the teasing is being reacted to.

When one suddenly comes upon a covey of young quail, there is immediately a tremendous fluttering in the brush and then an absolute quiet. The young birds have reacted to the situation of a man's presence by running to cover and then remaining absolutely still. The lack of movement is as much a part of the response as the scurrying to cover. Here is inhibition of movement as a type of response. Careful examination of the young birds while playing 'possum would indicate emotional activity, so that this lack of movement is not complete but only of those muscles pertaining to movements of limbs and body.

In every-day life we are much more likely to overlook responses to a situation which cause lack of bodily movement than of responses where the individual does something. Sometimes the absence of movement, when ordinarily movement is to be expected, is just the response to be noted. For example, candy having disappeared from a table drawer, three children are suddenly confronted with the question, "Who took the candy?" Two chorus out "Not me! What candy?" The third, after ten seconds, in a more subdued voice, responds "Not me." The temporarily inhibited reply and the entire

absence of interest in "what candy" clearly prove the presence of important elements in the situation to which the third child is responding that are absent in the case of the other two.

Interference between two responses to the same situation is sometimes the cause of no response to a situation. For example, as in Lesson 17, an individual might have responded to the letter "m" by the numeral "47," since "m" was shown with "47" three times. But if "m" had also been shown with "12," this same individual would quite likely make no response to the letter "m." Closer observation of him would have shown signs of irritation, for failure to respond due to interference of bonds is usually accompanied by emotional disturbance.

The response is the sum total of the behavior brought about by a situation affecting an individual. It includes movements produced by the large muscles of the body or of the small muscles within the body, and the total of consciousness involved therein.

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LESSON 39. HOW DOES ONE ESTIMATE DISTANCE?

In Lesson 37 we discovered that the visual impressions received by the two eyes are not identical. And the same fact was discovered concerning two sterescopic pictures. Moreover, we ascertained that there was a greater difference between those details of pictures which were in the foreground than between those in the background. Depth or perspective is clearly added to a picture when two views thus constructed are seen together. How is this accomplished?

The two eyes must rotate more (converge) when fixated on a near object than on a distant object. From experience, we have learned when we fixate on a string attached to a window curtain that (a) it is this string (not some other object) and (b) it is about so far from us. The object aspect of the response is due to stimulation of the retina by waves of light from the string, which in turn transmits a stimulation over the optic nerve to the brain. The distance aspect is due to the kinaesthetic sense-organs in the muscles that rotate the eye in order to fixate it on the string. They are stimulated to a certain extent and this stimulation is also transmitted over the nerve to the brain. There these particular stimulations cause us quite unconsciously to add to the object-aspect the idea of the string being located so far from us. The total perception—string so far from us—is a fusion, then, of visual and kinæsthetic stimulations.

Photographs taken for a stereoscope are taken by two cameras placed side by side but somewhat farther apart than the distance between the two eyes. The photographs over-emphasize the difference in the two views as seen by the two eyes. When placed in a stereoscope, one must converge his eyes more in order to have both eyes fixated on near objects than on distant objects in the two pictures. Consequently, we think of them as nearer because always in life when we have to converge our eyes upon an object it is nearer than an object which requires less convergence.

The above is the explanation of how in binocular vision we determine distances up to 100 feet. At 100 feet the eyes are both fixated straight ahead. Consequently there can be no greater divergence for objects beyond this distance than for 100 feet and, accordingly, we can not estimate distances beyond this distance on the basis of convergence and divergence.

Now how do we estimate distance up to 6 feet with monocular vision, and, second, how do we estimate distance beyond 100 feet? It is perfectly apparent that we can do both these things.

EXPERIMENT

Problem: What are the Factors Underlying the Perception of Distance? (Continued.)

Apparatus. Three pins.

Procedure:

(1) Have S close one eye and then have him note the changes that occur in the appearance of a pencil and the resulting sensations in the eye as E moves a pencil towards and away from the eye within the limits of an inch and six feet. Is S ever at a loss to know just how far the pencil is from him?

(2) In order to determine how accurate is S's ability to estimate relative distances, stick two pins into the far end of a table, say six feet from S. The line of the two pins should be perpendicular to S's line of vision. Now place the third pin between the other two sometimes in front of them and sometimes behind them and ascertain how accurately S can determine the relative distance of the middle pin as compared with the two outside pins. When this has been done, repeat the experiment, S using only one eye.

Just as a camera has to be adjusted for focusing on near and distant objects, so the lens of the eye has to be correspondingly adjusted. As has been pointed out in Lesson 36, these adjustments are made by contractions or relaxations of the ciliary muscle which is attached to the lens. Located in and about the ciliary muscle are kinaesthetic sense-organs. Ordinarily we are unconscious of the sensations

aroused by these sense-organs. But when the pencil is brought close to the eye, the strain in the ciliary muscle, in order to secure a clear focus, is so unusual that we notice it. Altho we are not ordinarily conscious of the kinaesthetic sensations caused by movements in the ciliary muscles, yet we act in terms of them. That is, thru experience we have learned that when the eyes are focused on a very near object, the ciliary muscle is under a certain strain, whereas when the object is farther away this strain is different. Consequently when confronted by an object, the first reaction is to focus it on the retina (a reflex act unconsciously done). We then receive (a) visual stimulations from the object which give us our knowledge of the object and (b) kinaesthetic stimulations from the ciliary muscle which give us our knowledge of the distance of the object from the eye. Rather the two— visual and kinaesthetic — sensations fuse together and we perceive such and such an object at such and such a distance. The above mechanism is an aid to us in estimating short distances of say six feet and less.

(3) Can an individual blind in one eye utilize the factors involved in binocular vision in estimating distance? Recall the details discovered in Lesson 37, part 2, with the books C and D. Note also in the same way, but with one eye, the differences in the view of book D obtained by swinging the head from side to side.

Repeat the above procedure, but, instead of moving the head from side to side, walk from your window to the next and note such changes as may occur in the view of objects at a considerable distance from you.

(4) Finish up your study of the other factors involved in the estimation of the distance of objects over 100 feet away.

Results: Report your results in the best way you know to bring out the principal points of the experiment.

Questions: (1) In what way does one estimate distances up to six feet?

(2) In what way does one estimate distances of from 6 to 100 feet?

(3) In what way does one estimate distances over 100 feet? Consider also the following questions in this connection:

a. If one did not know the size of an object, say a low hill, would that affect his estimation of its distance? Why? Explain.

b. Is the same distance estimated differently on a foggy day from what it is on a clear one? Why do Easterners underestimate distance in Colorado?

c. Do differences in color affect the estimation of distance? How? Why?

d. Which is easier to estimate the distance of, (a) a man walking along a road, (b) an auto, (c) a train along a railroad track, or (d) an aeroplane in the air? Why? How is the estimation made?

e. What part can a shadow play in the estimation of distance?

Application:

Write up your experiment and hand it in at the next class-hour.

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It is not necessary, nor is it expected of students, to consult these references in writing up the experiment. They are listed here for the use of any who are interested and wish to devote *extra* time to the subject.

LESSON 40.—THE MECHANISM OF THE CONNECTING SYSTEM. THE NERVOUS SYSTEM*

We now have a fair conception of how a sense-organ is stimulated into activity by outside agencies. We also realize that when a muscle or a group of muscles is stimulated, it contracts and moves a portion of the body. And, from the illustrations given in Plates XXX and XXXI, we have obtained a general notion as to how the stimulation received in the sense-organ is finally transmitted to the muscles and they in turn react. In those three examples we have cases in which the current flows from the skin to the muscle (a) by way of the spinal cord, (b) by way of the mid-brain, and (c) by way of the cortex of the brain. About these three examples we can build a great deal of the total conception that is necessary in understanding the connecting system.

The first three points to get clear in understanding the nervous system are: First, *sense-organs are connected with muscles by way of a central station in the spinal cord, mid-brain, or cerebrum.* Second, *the nervous system is made up of these three centrals together with nerve-fibres running to the sense-organs and to the muscles of the body.* Third, *the function of the nervous system is to connect sense-organs with muscles.*

In order to obtain a clearer, more accurate conception of the connections which are made possible by the nervous system, it will be necessary to obtain a better notion of the anatomy of the nervous system.

THE NEURONE

The nervous system can be roughly divided into four parts: (1) The spinal cord, (2) the mid-brain, (3) the cerebrum, and (4) the nerves that connect these parts with sense-organs and muscles. All of these four parts are composed of something like 11,000,000,000 nerve-cells combined in various ways.

The *neurone.* In Plate *XXXIV* are shown six different nerve-cells or neurones as they are more often called. At first glance they do not look much alike. A closer study will show that they all have certain characteristics in common. Each nerve-cell has (1) a *cell-body* and (2) certain projections from the cell-body called *filaments.* The cell-body is composed of protoplasm and has a nucleus. The filaments

*CLASS-HOUR	IN CLASS	WRITE-UP	READ
40	Discuss, Les. 38, 39		Lesson 40
41	Discuss, Les. 40		Lesson 41
42	Discuss, Les. 41		Review, Les. 34-41
43	Review, Les. 34-41		Review
44	Examination		

can be divided into two kinds: the axon and the dendrites. A nerve-cell has one *axon* but it may have many *dendrites.* The axon can be likened to a cable of telephone wires. It is made up of many fibrils similar possibly to the separate wires in the cable. Around these are one or two sheaths, possibly of an insulating character but more probably for the purpose of supporting and nourishing the fibril core. Axons may be infinitesimally short or up to five feet in length in man. Ordinarily they have few subdivisions. A bundle of such axons make up a nerve. The other type of filament, the dendrite, is usually quite short and much branched, often suggesting a bush.

The neurone has certain characteristics in common with all living cells. It is *irritable,* by which is meant that it responds to certain stimulations. It possesses *conductivity,* by which is meant that a stimulation at one point of its body is transmitted to any other part of its body. Besides these two, it probably has also the function of either *reinforcing or inhibiting the impulse* communicated to it. To illustrate the reinforcing function, consider the fact that a relatively slight pull on the trigger of a gun will produce a relatively great response. The stored-up energy in the cartridge is set off at the slight impact. In somewhat the same way a nerve-cell may be only slightly stimulated but it may respond in such a way as to stimulate very much more strongly the next cell in the series. The neurone as a whole then receives and transmits stimulations and in doing so may increase or decrease the intensity of the stimulation.

Turning now to the functions of the various parts of the neurone, we must note that "the cell-body has the highly important function of serving the nutrition of the whole neurone; it is necessary for maintaining the axon and dendrites in proper condition for work, even tho it may take no peculiar part in the actual doing of the work."*

The axon carries impulses away from the cell-body, while the dendrites receive impulses from without and transmit the stimulation toward the axon. In thinking of the neurone as a link in the chain connecting a sense-organ and muscle, we must always think of the current first stimulating the end of a dendrite and of it then being transmitted over the dendrite to the axon and out the axon. The nervous current never flows in the reverse direction.†

THE SYNAPSE

The *synapse* is the point of contact between an axon and a dendrite. It is still a debated question whether there is actually a gap between the axon and dendrite or not, but it is certain that as far as their

* Ladd and Woodworth, Physiological Psychology, 1911, p. 288.

†The above is true except in the case of the sensory neurones connecting sense-organs with the spinal cord. Here the axon on leaving the cell-body divides and one branch goes to the sense-organ and the other into the spinal cord.

function is concerned we may speak of the synapse as a functional gap. From physics we know that a weak electrical current will jump across a small gap in the form of a series of small sparks, but it will not jump a large gap. If the strength of the current is increased, the current will again jump the larger gap in a series of larger sparks. The smaller the gap, then, the less the resistance and consequently the smaller the current needed to jump the gap. This conception was early applied to the synapse. It was supposed that the dendrite and axon actually moved toward or away from each other and in doing

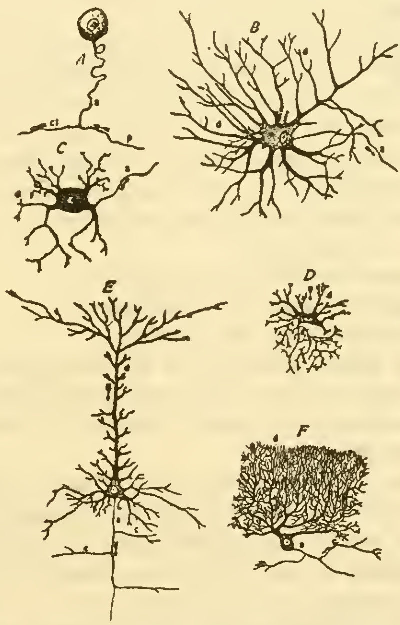

Plate XXXIV. A. cell from the spinal ganglion; B, cell from the ventral horn of spinal cord; C, cell from the sympathetic, D, cell from the spinal cord; E, pyramidal cell from the cerebral cortex; F, cell from the cerebellar cortex; a, axones; d, dendrites; c, collaterals; p, peripheral part of the fibre; cl, central part. Arrows indicate the direction of conduction for nervous impulses. (Modified from Morris and from Toldt.) (From J. R. Augell, Psychology, 1909. Figure 2).

so decreased or increased the resistance to the nervous current. This physical conception has been discarded and in its place is now a chemical one. Due to chemical changes in the dendrite and axon, the resistance is changed.

It is a well-attested fact that the nervous current flows over an axon at about the rate of 100 feet per second, or approximately an inch in 0.0008 second. But it requires 0.004 second for the current

to cross a synapse, an extremely short distance. This rate across a synapse is, moreover, for a well used synapse. It is quite likely that the rate is much slower for a little used synapse.*

Modern psychology makes much of the synapse with its great resistance to the passage of the nerve impulse, together with its changing resistance, in explaining the formation of habits. A habit or memory is today conceived of as due primarily to the chemical change in the synapse whereby the resistance is lowered, thus permitting the nervous current to flow in this particular direction rather than in some other direction. (Review here the discussion in Lesson 16 under the heading "Physiological Basis for Retention.")

FUNCTIONING OF THE NERVOUS SYSTEM.

By this time it should be clear that all kinds of behavior are essentially composed of one or more sense-organs and one or more muscles, with their connecting neurones. In some cases the sensory neurone directly stimulates the motor neurone, in other cases many neurones are interposed between the two. We may then divide up all action of man on the basis of these interposing neurones. Very roughly speaking we can speak of *three levels*:—

(1) Connection thru the spinal cord.
(2) Connection thru the mid-brain.
(3) Connection thru the cerebrum.

The three levels differ primarily in the directness with which the transfer is made: the higher paths permit more connections and make possible the cooperation of a greater number of sensory impulses in the control of movement.

The Lower Level—Spinal Level, (See Plates XXX and XXXI.) An essential trait of the lower level has already been repeatedly pointed out, i. e., a direct stimulation from the sense-organ results in an immediate response by an appropriate muscle. Examples of such reflexes are: (1) jerking the hand away from a hot stove, (2) withdrawing the part from tickling, etc. In reflexes we have the resulting proper action, because our nervous system has been developed thru ages of experience to act this way. In other words, we do not learn reflexes; they are organized naturally, just as hair grows on our head naturally, or teeth appear in our mouth.

Thus far we have considered the simplest form of reflex act—due to the union of one sensory neurone and one motor neurone. But we may have reflexes in the spinal cord where a few or many connecting neurones intervene between the sensory and motor neurones. If one destroys the brain of a frog it will be seen that all the customary

*A. T. Poffenberger, Reaction Time to Retinal Stimulation, Archives of Psychology, 1912, Chap. VII.

reflexes may be called out by appropriate stimuli. If a bit of paper moistened with acid be placed upon the left foot of a frog: (1) the leg will be drawn up—a simple reflex. If now the foot be held so that it cannot be moved, it will be found that (2) the other foot is brought over to remove the stimulus. If this is not successful, (3) the muscles of the forelegs and trunk will contract and the contractions will continue until the stimulus is removed or the organism becomes exhausted. (The same phenomenon can be obtained thru tickling a person who is asleep.) What has happened in all these cases? In Plate XXXV is shown very roughly the organization of the neurones involved in such cases. In the first case the current travels from S (the sensory neurone) to M, a motor neurone. With continued stimulation received via S more and more motor neurones are brought into play, as M2, M3, M4, M5, etc. What is much more likely to happen is depicted in the right hand part of the Plate where an inter-

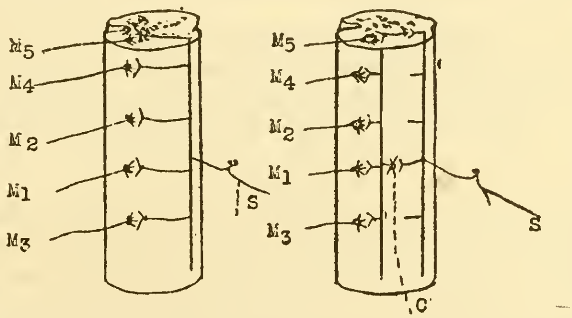

Plate XXXV. Showing how a sensory neurone (S) may be connected directly with various motor neurones (M) or indirectly by means of connecting or intermediate neurones (C). From J. D. Lickley, The Nervous System. 1912, p 40.

mediate or connecting neurone (C) is included. Here the current travels from S to C and then to M1, or M2, M3, etc.

Now why have there been these changes in response? We must suppose that continued stimulations result in an increase in the nervous current which is generated. With a slight amount of current the flow is over the most usual pathway because of less resistance at the synapse. When that pathway is blocked, the next easiest pathway is used. And with greater and greater amounts of nervous current coming in over the sensory fibre, greater and greater resistance can be overcome, resulting in more and more widely separated motor cells being stimulated—hence in more and more extended muscular con-

tractions. (Review at this point the conception of "overflow of energy" given in Lesson 19.)

The Intermediate Level—Mid-Brain Level. The mid-brain, or brain-stem, is the upper end of the spinal cord. In this elementary course it is impossible to consider the parts of the mid-brain separately, and so all of them will be considered together. Their functions are very complex, but after all they may be reduced to the same ones which appear in the spinal cord, i. e., connecting sense-organs with muscles, and more particularly connecting impressions from many sense-organs together so as to have the most appropriate muscular response to all the sense-organ impressions. The functions of the mid-brain are:—(1) to serve as reflex centers by which the sense-organs of the head may be connected with the muscles of the head. To illustrate, note these examples. According to the amount of light striking the eye, the pupil is wide open or shut. These movements of the pupil result from stimulations from the retina going to the mid-brain and back again to the muscles governing the pupil. In the same way most of the movements of the eyes are governed from the mid-brain. The medulla, a part of the mid-brain, receives organic stimulations from the various parts of the body and in turn stimulates the muscles of the heart, blood-vessels, etc., so as to control the rate and force of the heart-beat, the diameter of the blood-vessels, etc. The function of the mid-brain is (2) to connect the special sense organs of the head with the motor neurones of the spinal-cord, and so with the muscles of the trunk and limbs. For example: putting the hand up to protect the face, jumping at a loud noise, kicking backward as the result of a blow on the head from behind. (3) to connect the cortex of the brain with sense-organs and with muscles. It is probable that all the sense-organs excepting smell, are represented in the mid-brain by neurones, and that in every case the impulse from a sense-organ is relayed from neurone to neurone in various ganglia in the mid-brain. The mechanism of the reflexes in this level is then the same as in the lower level. The only difference is that the causes of excitation are more numerous and the possibilities of connection are greater.

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ASSIGNMENT

The next laboratory hour (Lesson 41) will be devoted to a discussion of this Lesson.

LESSON 41. THE NERVOUS SYSTEM OF MAN (Cont'd)

It has already been pointed out that nerve action can be roughly divided into three parts:

(1) Spinal level—connection is made in the spinal cord.

(2) Intermediate level—connection is made in the mid-brain.

(3) Cortical level—connection is made in the cerebrum.

The first two have already been discussed in Lesson 40. We are consequently ready to consider the third level.

THE CEREBELLUM..

See Cb of Plate XXXVI, and the smaller body just above "TA" in Plate XXXVII for the location of the cerebellum. The cerebellum belongs to the mid-brain level from its position, but because of its cortical structure it may be considered here. It is very richly connected by neurones with the lower centers and with the cerebrum. But we know very little about its functions. However, it seems to be agreed that its functions are most intimately related to the reception and coordination of the senory stimulations which originate *within* the body itself, e. g., in the muscles, the viscera, the semi-circular canals of the ear, etc. It is thus conspicuously involved in such actions as those by which we preserve our *equilibrium* and in general succeed in carrying forward well coordinated and balanced movements, like walking, sitting, and standing.

THE CEREBRUM

Many stimulations from sense-organs are relayed in to the cerebrum, are there combined into an organized whole and then relayed out to the muscles resulting in coordinated movements in harmony with the stimulations received by the sense-organs. The activity may be likened tc the army organization. Information is obtained by the soldiers and lower officers while on scouting duty. This information is transmitted

up thru the various officers until it finally reaches the commanding officers. These officers, in turn, tranmit orders back down thru the various officers until finally the soldiers execute them. A general ordinarily neither receives information from a private nor gives him commmands. So with the brain, it never receives stimulations directly from the

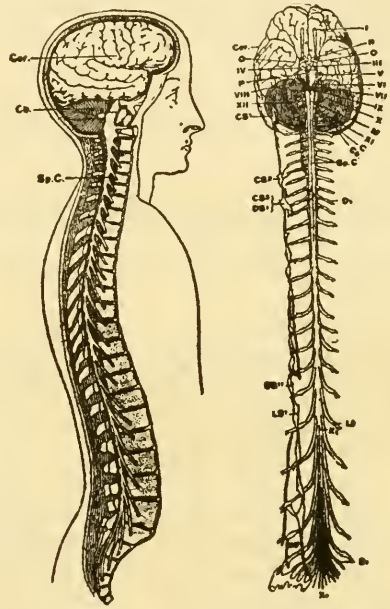

Plate XXXVI. The figure at the left shows the general relations of the central nervous system to the bones of the skull and spine. The figure at the right displays the general contours of the central system as seen from in front. The great ganglionated cord of the sympathetic system is shown attached to one side of the spinal nerves; the other side has been cut away. (Cer) the cerebral hemispheres; (O) the olfactory centers; (P) the pons Varolii; (M) the medulla oblangata; (Cb) the cerebellum; (Sp. C) the spinal cord; (I) the olfactory nerve; (II) the optic nerve; (III) the oculo-motor nerve; (IV) the trochlear nerve; (V) the trigeminus nerve; (VI) abducens nerve; (VII) the facial nerve; (VIII) the auditory nerve; (IX) glossopharyngeal nerve; (X) the vagus nerve; (XI) spinal accessory; (XII) the hypoglossal nerve; (C) the first cervical spinal nerve; (D1) the first dorsal, or thoracic nerve; (L1) the first lumbar nerve; (SI) the first sacral nerve; (XI) filum terminale; (CSI) superior cervical ganglion of the sympathetic; (CS2) middle cervical ganglion of the sympathetic; (CS3) and (DS1) junction of the inferior cervical and the first dorsal ganglion of the sympathetic; (DS11) the eleventh dorsal ganglion of the sympathetic; (LS1) the first lumbar ganglion of the same system; (SS1) the first sacral ganglion also of the sympathetic. From J. R. Angell "Psychology," 1909. (Figures 12 and 13.)

sense-organs (excepting smell) nor directly stimulates muscles to move. The lower and intermediate levels of activity stand in between. Consider another illustration. The problem 673 x 48 is given one to solve. Light waves from the paper containing the problem strike the retina. The physical stimulation is changed into a physiological proc-

ess which is transmitted over the optic nerve to the mid-brain. Here part of the stimulation is directed to muscles controlling the eye and head and they so move as to permit one to see the problem in the best light, etc. The remainder of the stimulation is relayed to the cortex of the brain. Due to long established habits the stimulation is then sent from the cortex back thru the mid-brain down the spinal cord and to muscles of the arm and I find myself reaching for pencil and paper and solving the problem.

It is probable that only connections made in the cerebrum are *conscious.* That is, consciousness accompanies only cortical activity.

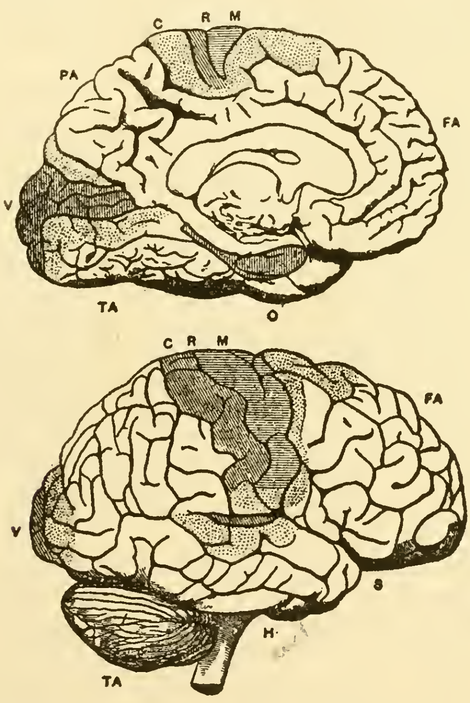

Plate XXXVII. "Localization of Cerebral Function. The lower figure shows the outer surface of the right hemisphere; the upper, the mesial surface of the left hemisphere. In both figures the motor areas are marked by horizontal shading, the sensory by vertical shading, while the associatory areas are unshaded. The doubtful or partially sensory or motor areas are indicated by dots. (S) is opposite the fissure of Sylvius; (R) above the fissure of Rolando. (M) is above the motor region; (C) above the cutaneous and kineasthetic area. (V) indicates the visual region; (O) is below the olfactory region. The auditory region is just below the fissure of Sylvius, above (H). (FA) designates the frontal, (PA) parietal, and (TA) the temporal association centers. There is some evidence that the dotted regions about the sensory and motor areas are areas in which particular associations are formed with them. The diagram embodies the results of A. W. Campbell, but has been modified in one or two respects to agree with the results of Flechsig and Cushing." (From W. B. Pillsbury, "The Essential of Psychology, 1911, Figure 7, published by the Macmillan Company.)

The cerebrum is composed of two hemispheres joined together by what is called the *corpus callosum.* This is shown in Plate XXXVII as a sort of crescent shaped area in the center of the upper illustration. This represents the cut-end of the callosum as it must need be severed in order to show the inner surface of one of the hemispheres. It is made up of fibres which connect one hemisphere with the other. Two landmarks need to be pointed out: the *fissure of Rolando* and the *fissure of Sylvius.* The former is marked by the letter R in the plate and the latter by the letter S.

Recent study of the brain has shown that certain areas of the cerebrum are concerned with certain functions, some being primarily concerned in receiving stimulations from the sense-organs and others in controlling movements in the body.

Sensory Areas. (1) Cutaneous sensations are localized just back of the fissure of Rolando (marked by a C in the plate). Stimulations from the leg are localized at the top of this area and over on the inside surface, stimulations from the trunk are localized further down toward the fissure of Sylvius, and stimulations from the head at the lower end of the area not far from the fissure. Destruction of this area does not affect all varieties of cutaneous sensations equally. "The pain sense is little or not at all affected, except temporarily; the sense of presssure and contact is considerably more diminished; the temperature sense is so much reduced that only extremes of heat and cold are perceived: the muscular sense is almost entirely destroyed; and the perception of form, size, location, etc., by use of the hand is usually abolished."*

(2) Visual sensations are localized in the occipital region of the cerebrum, marked by a "V" in the plate. "It would appear likely that the retinas are projected, point for point, tho perhaps not quite so minutely as this, upon the visual cortex."**

Injuries to certain parts of the visual area produce blindness as related to corresponding parts of the retina. We may speak of two types of localization here: one which deals with the reception of the simple stimulations received from the eye—corresponding to awareness of brightness or color, and the other which deals with the interpretation of these simple stimulations going to make up definite objects, as yellow square, a house, or what not. Injuries to the more outlying parts of the visual area result in loss of ability to recognize objects, or to read, or to utilize vision for purposes of orientation. In such cases the patient can still see, but has lost some of the uses of sight. Such cases are referred to as psychic blindness.

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*Ladd and Woodworth, op. cit., p. 245.
**Ladd and Woodworth, op. cit., p. 248.

(3) Auditory sensations are localized below the fissure of Sylvius, and appear a little above where the H occurs in the plate. Injuries to this area, as in the case of the visual area, produce total deafness or psychic deafness. The latter is illustrated by such cases as inability to understand spoken words, or to apprehend melodies.

(4) Olfactory and taste sensations are located in a great loop about the corpus callosum.

The Motor Area. Voluntary control of muscles of the body is located in an area just across the fissure of Rolando from the cutaneous sensation area. And here again as in the case of that area, the legs are represented by the upper part of this area, the body next, the arms next, and the head at the lower end. In this area are the largest nerve-cells in the body. Their axons descend thru the mid-brain and cells. Axons from the latter proceed out to the muscles of the body.

In paralysis we have a condition in which the motor connection spinal cord and there come in contact with the dendrites of other motor with the muscle has been destroyed. If the injury is in the motor-cells of the cerebrum the paralysis relates only to voluntary movements, while reflexes of the spinal and mid-brain level are not ordinarily affected. If the injury is in the spinal cord but above the motor-cells in the cord then the mid-brain reflexes are destroyed as well as all habitual movements. If finally the injury is in the motor-cells of the spinal cord then there results complete paralysis of the muscles of the body controlled from that part of the spinal cord.

Another type of paralysis is due not to a destruction of the motor connections but to a destruction of the sensory side of the arc. This type is found, for example, in tabes dorsalis. The incoming kinaesthetic sensations are largely eliminated because the sensory connections are destroyed. Walking is seriously interfered with because you cannot sense just where your leg is at any moment. Thru training such individuals may be taught to guide their movements not as they have done in the past in terms mainly of kinæsthetic stimulations but in terms of visual stimulations. In this way they are able to walk with little suggestion of "drunkenness."

The Parietal Lobes (marked PA in the Plate) are situated between the cutaneous sensation area and the visual area. Injuries to these lobes are distinguished by disturbances in ability to connect ideas and sensations with their proper companions. For example, a file touched in the dark does not call up the idea of a file as seen. In other words, things seen are not connected up with their auditory or tactual appearance and hence are improperly understood and interpreted.

Frontal Lobes. Injuries to the frontal lobes seem to be marked by

"disorders of attention," concentration, and the higher mental and emotional capacities. "An addiction to practical jokes of a weak order, with lack of respect for property or the rights of others has been frequently observed. On the other hand, in some remarkable cases of destruction of large parts of the frontal lobe, no marked symptoms whatever have appeared." This is true more particularly of the right frontal lobe than of the left. Franz first taught a cat and monkey a trick, then removed parts of the frontal lobe. In general the trick was no longer known. Injury to only part of the lobe resulted in simply slowing down the time of performance. Franz concludes that "the frontal lobes are concerned in the acquisition of new performances, but that no one spot is indispensable for the acquisition of a particular act; and that long continued practice in a performance reduces it to an automatic or semi-reflex condition, in which the frontal lobes are no longer necessary."*

Association Centers. A rather small portion of the surface of the cortex is thus far accounted for. How shall we explain the function of the remainder of the brain's surface? The best authorities would explain the function of this remainder as one of *association,* or of connection. By this is meant that here the stimulations from the various sense-organs are combined together, thus affording responses which are appropriate to the whole sensory stimulation.

For example, the reflex act would be to drop a flat-iron, if the handle were too hot. But if there were a kitten on the floor at one's feet the resulting action would be to throw the iron into a corner or to hold on to it until safely replaced on the stove. In the second case the reflex act is prevented by the visual stimulation—the sight of the kitten. In such a case the cerebral cortex was directing the movement of carrying the hot iron. The reflex act of dropping was inhibited (when the iron was put back on the stove) or directed into a new movement (throwing the iron) by the stimulation coming from the eye. The association centers are supposed to be responsible for such coordinated action.

Before leaving this subject attention should be called to the fact that the four phases of knowledge of a language are generally considered to be located in four different parts of the cerebrum. Ability to read is localized in the visual area, ability to understand spoken words is localized in the auditory area, ability to speak is localized in the motor area near the center governing muscles of the head, and ability to write is localized in the motor area near the center governing arm movements. It is then possible thru a particular brain injury to lose the

*Ladd and Woodworth, op. cit., p. 262-63.

ability to read but still to understand what another says, or to speak himself and, what is even more surprising, to be able to write, altho, of course, unable to read what he has written. The teaching of English, for example, must consequently be viewed as the development of four groups of habits, instead of one. It is not enough to train a student to write good English; he must also be trained specifically to speak good English. There is no doubt that training in one of these four groups aids in the other three. But too much reliance has been placed upon this in the past Since it is a fact that the brighter the child the greater will be this transfer, and the duller the child the less the transfer, teachers should deliberately aim to develop all four groups for the sake of the dull child.

FUNDAMENTAL AND ACCESSSORY SYSTEMS

Another method of grouping the complicated functions of the nervous system is to refer to them under the two headings—fundamental system and accessory system. These terms are used so frequently it is desirable to become familiar with them in this course.

"The nerve-centers of vertebrates may be considered as consisting of (1) a *fundamental system*, comprising the spinal cord and brain-stem, and (2) *accessory organs* developed as outgrowths of the brain stem. the chief of these being the cerebellum and cerebrum. (See Plate XXXVI.) The development of the accessory structures is very unequal in different forms of vertebrate animals: the size of the cerebellum being closely related to the animal's powers of locomotion, and the size of the cerebrum with his powers of learning new and specific adaptations. The fundamental system is, on the other hand, fairly constant thruout the vertebrate series. This is especially true of the spinal cord, the size of which seems to depend almost wholly on the size of the animal."*

The fundamental system consists of: (1) *Sensory ganglia* which lie just outside the spinal cord. (In Plate XXX of Lesson 34 one sensory neurone is shown extending from the skin to B into the spinal cord at L. Its nerve-cell is at K. A cluster of such nerve-cells is called a ganglia.) From these ganglia fibres extend out to the sense-organs of the body on the one hand and into the spinal-cord on the other. It is in this way that the sense-organs are connected with the spinal-cord, with the single exception of the sense of smell. Here the sense-organs send out their own fibres which extend into the brain. (2) *Motor-cells,* which lie within the spinal-cord, branches of which pass out to the muscles. (3) *Central-cells,* whose branches do not extend to sense-organs or muscles, but which run up or down or across in the

*Ladd and Woodworth, op. cit., 26.

spinal-cord and so bring all the different parts into connection. Most of these fibres are short, but there are some sets of long ones, which connect the spinal-cord directly with the mid-brain. The usefulness of these connecting fibres can be readily appreciated as by means of them the impressions from all the sense-organs may be combined and thus movements may result which are in harmony with the information received from eye, ear, nose, etc.

The accessory system is composed principally of the cerebellum and cerebrum. In terms of evolution, these are recent additions to the nervous system, as contrasted with the elements making up the fundamental system. The functions of these two organs has already been discussed. In addition, the accessory system is characterized by long nerve fibres which connect the cerebrum more directly with lower centers. These nerve fibres are spoken of as "long" in contrast with the short interconnections of the fundamental system. But the accessory system, as already pointed out, never receives stimulations from sense-organs (excepting smell) nor transmits stimulations on to the muscles except by the way of the fundamental system.

SUMMARY

Review again Lesson 34 at this point. Lessons 34 to 41 have been presented especially to give a more definite conception of what the terms "situation," "bond" and "response" mean. A *situation* means the sum total of all factors stimulating the organism. Physiologically the term comprises:

the external stimuli,
the stimulated sense-organs,
the transmission of the stimulation over the sensory nerve-fibres.

The term *bond* comprises:

the transmission of the stimulation from the sensory nerve-fibres to connecting (intermediate) nerve-fibres and from them to motor nerve-cells.

And the term *response* comprises:

the arousal of the motor nerve-cells,
the transmission of the stimulation over the motor nerve-fibres to the muscles.
the contraction of the muscles.

The most important phase of the whole series as it affects teaching is comprised in the term bond. For under this heading we group the formation of new bonds (the process of learning), the development of these bonds to a good working condition (development of skill thru practise), the future use of these bonds when the situation is again encountered (memory), etc.

LESSONS 42, 43 and 44. GENERAL REVIEW.

The 42nd class-hour will be devoted to a general discussion of Lesson 41.

The 43rd class-hour will be devoted to a general review of the whole course.

The 44th class-hour will be devoted to a final examination on the course.

GENERAL REVIEW OF THE COURSE

The course apparently divides up into three parts, i. e.—

1. The Learning Process.
2. Individual Differences.
3. Physiological Mechanism.

But the main conception around which everything else is built is that man's behavior must be thought of in terms of Situation, Bond and Response. In Lessons 34 to 41 the physiological mechanism was briefly presented so that the terms would be more correctly and definitely understood. In Lessons 1 to 20 various concrete cases were presented such as a lesson in the first grade, learning mirror-drawing, committing a vocabulary to memory, etc., and the various details analyzed into situation, bond, and response; and in Lessons 21 to 23 thru a study of individual differences it was pointed out that individuals differ as regards the inherent make up of their nervous-system (i. e. the inherent nature of the "bond") and also because they have had different situations presented to them in the past to which they have reacted. (That is, the environment has differed and hence their training, since training is a resultant of bond changes due to reacting to situations.)

Learning is reduced consequently to making connections—forming new bonds. And *teaching* becomes the art and science whereby proper situations are presented so that children will react as desired. In so reacting new bonds are constantly being formed and old bonds as constantly being strengthened thru use. Lessons 45 to 88, which appear as another volume, are devoted to a much more detailed consideration of this whole subject.

Due to the fact that individuals are confronted by different situations in life and that there are great differences in the structure of their nervous systems, no two persons learn in exactly the same way or with the same facility. On the whole the majority of individuals are much alike and can be handled en masse, but many learn much more rapidly than this average group and as many learn less rapidly. Because of this condition, in order to handle children efficiently in school, it is necessary to analyze the causes of each child's behavior in order to

prescribe the proper methods for his greatest development. This is being done in many cities today with respect to the dullest of children but it must be done eventually with respect to all pupils before we shall have arrived at a scientific type of instruction.

Realization of what this problem of individual differences means gives us a new point of view with regard to the whole subject of education. And not only must we view education in a new way but also all social problems. The handling of the criminal, of the pauper, of the incompetent worker, etc., becomes a different proposition. Already, on every hand, are there evidencs that the new point of view is having its effect. Changes in our penal institutions, the rise of Juvenile Courts, of indeterminate sentences, of parole from penitentiaries, the interest in eugenics, in scientific vocational guidance, in personnel work, etc., are all related to each other—all manifestations of this same new point of view, altho expressed, it is true, very differently by different workers.

In the field of education the overlapping of children in the several grades is being studied from many angles and ere long a more satisfactory solution to this phase of individual differences will appear. The old schemes for grading students are doomed and new ones based on our further knowledge of how children differ are taking their place.

The student who has not simply learned about these things but has formed the habit of analyzing educational problems into situations and responses has gained something which will help him in all his work. As an aid in making such analyses this course has been devised to develop the habits of thinking about learning in terms of a curve and of reacting to a problem by asking these questions:

(1) What specifically is my problem— the problem.
(2) How may I study this problem—the procedure.
(3) What are my facts—the results.
(4) What do the facts mean—the interpretation.
(5) How can I use the deductions—the application.

Whether a student has gotten these things from the course or not eventually comes down to whether he has the ability to acquire such complicated conceptions (bonds) and has had the industry to develop them.

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